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Cushing, New York

Night Spectacle at the New York World's Fair

(Statue of George Washington against a background of searchlight beams. The British-American Engineering Congress, Sept. 4–8, see pages 690 and 691, will hold sessions on the Fair Grounds.)

VOLUME 61
No. 9

MECHANICAL ENGINEERING

SEPTEMBER
1939

GEORGE A. STETSON, *Editor*

New England Enterprise

AN EXAMPLE of enterprising publicity and service to engineers that might be followed with profit by engineering groups in other localities is to be found in a useful publication of the Engineering Societies of New England, Incorporated, whose headquarters are in Boston, Mass. This organization, conscious of the fact that many engineers en route to the New York World's Fair may pass through New England, has issued a general invitation to visitors to have a look at engineering plants and has prepared, in inexpensive form, a list of "Works of Engineering Interest in New England to Which Engineering Visitors Are Welcome."

The publication provides a convenient tabulation that names the plant available for inspection, its location, a brief description of it, and the name of the person to call on and his address. The plants are grouped under civil-engineering works pertaining to transportation, structures, hydraulics, and sanitation; mechanical-engineering works pertaining to power generation and manufacture; electrical-engineering works pertaining to power generation, distribution, communication, and equipment manufacture; and chemical-engineering works.

This looks like a good proposition from all points of view. It is certainly a convenience to visitors to have such lists available from which essential information may be derived with a minimum of trouble. It is evident that any plant listed welcomes visitors or its name would not appear. Knowing the proper person to approach is of great help to visitors. And the engineers who back the project, the communities in which the plants are located, and the plants themselves enjoy a high quality of publicity. The preparation of similar lists covering other industrial districts should provide local engineering clubs and local sections of national societies with a useful project and save individual engineers much time when their friends from out of town drop in and want to be told how to get in to the XYZ manufacturing company, whom to see, or what local plants are open to visitors.

What Is Mechanical Engineering?

TWO of the principal benefits to be derived from an engineering education are (1) a study of the basic sciences and some of their applications, and (2) discipline in the use of the scientific or engineering method. Frequent use of the fundamentals of science increases the engineer's ability to apply them, and daily experience with old and new applications broadens his engineering vision and skill and adds to his knowledge. What makes this growing body of knowledge and experience effective is the technique with which it is applied in the solution of new problems and the performance of unusual tasks. This technique is known as the scientific or engineering method. The combination of engineering knowledge and the engineer's method of using it successfully makes a great engineer. Moreover, the value of the engineer to society lies not so much in his knowledge of applied science and materials as it does in the effectiveness of his methods of thought and work. This combination of special knowledge and effective method opens to the engineer a broad field of service and a wide variety of ways in which to exercise his rich talents.

To supplement the student engineer's study of the fundamental facts and principles upon which engineering practice is based and his training in the engineering method by which this knowledge is applied, engineering societies and publications are brought to his attention while he is still at school as a means of broadening his comprehension of engineering and his contacts with the engineering profession. For this purpose The American Society of Mechanical Engineers maintains student branches in 117 engineering schools and provides its student members with MECHANICAL ENGINEERING, the Journal of the Society. Inasmuch as the present issue is the first that many of the 6000 students who will become associated with the Society during the coming academic year will see, the Editor is taking this opportunity of spreading his wares before them.

Familiarity with textbooks and thermodynamics will make it easy for students to read and comprehend Mr. Hodgkinson's article in this issue. But there is more to it than an exercise in thermodynamics. It affords an example of heat-power bookkeeping, if you will, written with no academic purpose in view but to clarify thinking and discussion on the part of those who must make and accept guarantees of steam-turbine performance in which thousands of dollars may be involved. Incidentally, introduction to Mr. Hodgkinson, associate of the great Parsons and the great Westinghouse and one of the distinguished figures in the history of the steam turbine, should excite the interest of youth.

Still in the field of thermodynamics is the story of the gas turbine told by Adolphe Meyer, Brown, Boveri director, who has not hesitated to tackle a fascinating but elusive problem in which the energy of fuel is made available in the form of mechanical work in a rotating

machine without the intermediate step of generating steam.

Messrs. Hartig and Wilcox demonstrate how the research worker borrows techniques from one field of science to apply them in another—the essential ingenuity of scientific investigation. Almost anyone might think of throwing an object into a moving stream and computing the velocity by timing its progress between two points. These authors throw into the stream an electrically initiated sound, pick it up electrically at another point, and compute the velocity of flow thereby with amazing accuracy.

Engineers are always creating problems for one another. While one group is engaged in increasing the speed of trains another finds that it must devise better methods of retarding and braking those trains with safety. So Mr. McCune, following in the footsteps of the illustrious engineer who founded the air-brake industry, tackles the problem of the modern high-speed railway brake, and describes the principal developments that have taken place in this field recently.

The examples so far cited lie principally in what may be called the technical branch of the engineer's work. But there are other branches as well, and the engineer is successful in these not only because of his knowledge of applied science, his inventiveness, and his thorough research, but also because of his command of the engineering method of solving problems. Many laymen, for example, assume that a clever man conceives an idea, patents his invention, and the world then possesses a new device. But it is not as simple as that, as Mr. Stevenson shows. The long hard pull that may involve problems in a dozen branches of knowledge and the facing of stubborn engineering and commercial facts demand all the ingenuity and thorough application of the engineering method that not one man alone but perhaps a hundred men, coordinated in research laboratories, shops, finance committees, sales organizations, and publicity departments, can muster. The student engineer is likely someday to belong to one, and eventually, perhaps, to most of these groups. He cannot learn too soon to appreciate the size of the task ahead of him, the varied skills that must be exercised, and the technique by which new products progress from the mind of the inventor to the customer's use. Mr. Stevenson, who has trained hundreds of student engineers for the General Electrical Company, outlines this important and realistic problem.

Sound qualities of knowledge and experience and particularly the ability to exercise wisely the engineering method, throw engineers not only into contact with technical problems but also into human and commercial relationships in industry. The student engineer eventually faces problems of administration. In a history of management in this issue are recorded the significant steps by which engineers acquired a command of management principles—the application of the engineering method to industrial and commercial enterprises. This great field of human effort has been opened up to the engineer by the significant contributions to it that engineers have made.

Engineering spreads out over wider and more distant fields, and an engineering career, begun in design, research, production, or operation, may end in the director's office or the banking house. Research, even if it is concerned with apparently useless speculations on ultimate truth, is the seed corn of material progress, but a profitable harvest demands the practical arts of husbandry and economic common sense. Hence engineers turn more and more to economics, and to attempts to master the broader meaning of economic relationships. In addition to articles on economic subjects, this magazine publishes every month a review of a significant book on economics. In this issue this review deals with the important question of minimum wages, a problem that confronts the world of today as never before.

But these evidences that an engineer must have sound knowledge, must apply skillfully the engineering method, and must concern himself with administration and economics are fortunately supplemented this month by Mr. Doherty's article on the responsibilities of engineering as a profession. Engineers have only lately taken a serious view of their position as professional men. Indeed, in the country as a whole the professions have only recently begun to feel the force of public opinion on their professional status. A profession confers privilege; privilege imposes obligations. Thinking on this subject is none too clear and not too widespread as yet, but the student engineer of today will graduate into a world where the problems of a profession will demand attention and solution. It is well to realize this situation early and be prepared to meet it honestly and effectively.

Supplementing the full-length articles, several brief abstracts and comments are presented monthly for the purpose of tapping broader fields, of providing contact with day-by-day events that bear on the engineer's interests, and of introducing to readers, in human terms, a few men who have got into the news. This section, called "Briefing the Record," contains much solid fare in capsule form.

And lastly, there is the engineer's relation to other engineers and to the public that is maintained by national engineering societies—by The American Society of Mechanical Engineers. All the elements of engineering activity and interest so far mentioned are stimulated, advanced, and fostered by the Society and its publications. Every issue of MECHANICAL ENGINEERING is devoted to this great purpose and in every issue the *A.S.M.E. News* provides members of the Society with a means of keeping up contact with Society affairs.

No simple definition of mechanical engineering has been attempted here. The purpose has been to show, by specific reference to the contents of this issue, how broad and how diverse mechanical engineering is, and, incidentally, to convince the prospective student member that he should comprehend the richness and importance of the profession he is about to enter, that he should ally himself in the A.S.M.E. with his fellow engineers for the benefit of himself and the profession, and that he should keep in touch with the profession by contracting a lifelong habit of reading MECHANICAL ENGINEERING.

THE COMBUSTION GAS TURBINE

Its Present Stage of Development and Prospects for the Near Future

By ADOLPHE MEYER

BROWN, BOVERI & COMPANY, LTD., SWITZERLAND

THE TERM "constant-pressure gas turbine," hitherto generally employed to denote a turbine actuated by the steady flow of the products of a continuous combustion under pressure, is inaccurate. The expression, "constant-pressure turbine" was chosen to distinguish this machine from the constant-volume turbine, in which combustion takes place intermittently by explosion in a closed chamber with a substantial rise in pressure. In the so-called "constant-pressure gas turbine" neither the combustion-chamber pressure nor that before the turbine remains constant in service as, for instance, the steam pressure of a boiler; on the contrary, they depend on, and vary with, the load.

It is preferable, therefore, to call such a turbine a "continuous-combustion gas turbine," or briefly, "combustion turbine," in contradistinction to the explosion turbine.

OPERATION OF A SIMPLE GAS TURBINE

In Fig. 1, which shows the combustion turbine in its simplest form, *b* is the combustion chamber in which the gases are produced at a high temperature by the continuous combustion of some kind of fuel in an atmosphere of compressed air.

According to the fuel used, such turbines are referred to as gas, oil, natural-gas, blast-furnace-gas, or pulverized-coal turbines. With all these fuels, the temperature of the combustion gases is high and must be reduced to a value compatible with the creep strength of the gas turbine blading. This can be done either by the addition of a large excess of air, or by the injection of water, or by a partial abstraction of heat by water-cooled surfaces, or other similar means. Of these methods, cooling by injection of water must be ruled out of consideration, because of the loss associated with the latent heat of evaporation. The plant shown in Fig. 1 is based on the use of excess air as a cooling medium, and of oil as fuel.

The total quantity of air (combustion plus cooling air) is drawn from the surrounding atmosphere by the axial compressor *a*, compressed to the combustion pressure of the order of 20–30 lb per sq in. gage, and forced into the combustion chamber *b*. Part of the air serves as combustion air for the oil which enters the burner *d* at *c*, while the remainder is forced through the annular space between the wall of the combustion chamber and the burner jacket. Here it takes up heat from, and incidentally cools, the burner jacket, after which it mixes with the products of combustion, reducing their temperature to that admissible for the gas-turbine blading *f*. In this simplest form of gas turbine, the gases go straight from the turbine *g* to the chimney. The speed of the gas turbine is governed by controlling the fuel oil supply, and by means of a by-pass valve *h* which acts as a safety valve. In addition to the compressor referred to, the gas turbine drives the generator *i* either directly or through gearing. The only auxiliary machines of the plant are the starting motor *j*, which is of a size to insure the compressor supplying enough air to the combustion chamber for lighting up, and the lubricating and fuel-oil pumps.

It will be seen that the early inventors' aim to simplify the steam plant has been attained, there being no boiler with auxiliary equipment such as feedwater pumps and water-treatment plant, no condenser with circulating water, air-extraction, and condensate pumps, no water-supply system, or cooling towers. The boiler is replaced by a simple combustion chamber, although the compressor is now larger and more expensive than the forced- and induced-draft fans of a normal boiler installation.

The reason early gas turbines did not prove successful is indicated in Fig. 2, which shows the thermal efficiency of a gas-turbine plant of the type illustrated in Fig. 1, as a function of the over-all turbine and blower efficiency, and for different turbine admission temperatures. It will be noted that even with an over-all efficiency of 53 per cent, corresponding to a turbine efficiency of 78 per cent and a compressor efficiency of 68 per cent (values unlikely to be attained in early times), the efficiency of the gas turbine cycle with a gas admission temperature of 1000 F was zero, and would not have exceeded 5 per cent with a temperature of 1500 F, which even today is still inadmissible. The cause of this unhappy result must be sought in the great volume of compressed air required for mixing with the combustion gases to reduce the combustion temperature of approximately 3300–3600 F to a temperature which can be used with the gas-turbine blading.

Inasmuch as the explosion turbine is outside the scope of the present paper, it is accordingly impossible to discuss here the Holzwarth turbine, but it would be wrong not to acknowledge the enormous amount of work contributed during thirty years of unrelenting effort by Dr. Holzwarth and his collaborators to the development of the gas turbine, and not to say a

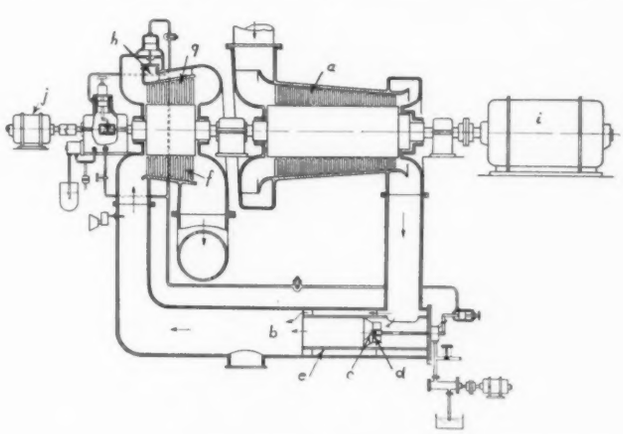


FIG. 1 DIAGRAM OF THE SIMPLEST FORM OF COMBUSTION-TURBINE PLANT

(*a*, axial compressor; *b*, combustion chamber; *c*, ignition point; *d*, burner; *e*, burner jacket; *f*, gas-turbine blading; *g*, reaction-type gas turbine; *h*, by-pass safety valve; *i*, electric generator; and *j*, starting motor.)

Contributed by the Oil and Gas Power Division and presented at the Semi-Annual Meeting, San Francisco, Calif., July 10–15, 1939, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Based on a paper presented before The Institution of Mechanical Engineers, London, England, Feb. 29, 1939, but including additional and more recent data. Part of the historical section and some of the illustrations that appeared in the original paper have been omitted.

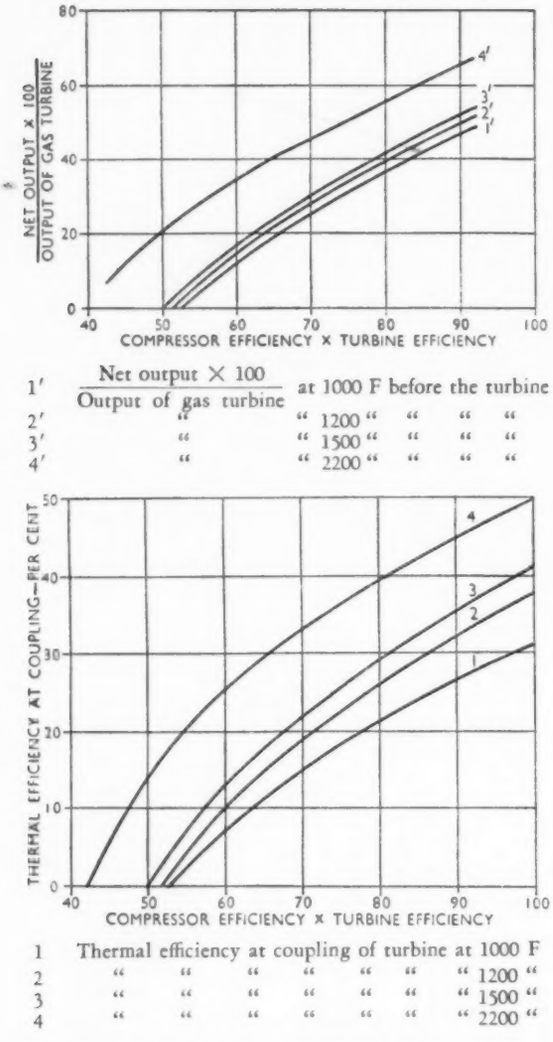

NET OUTPUT × 100 / OUTPUT OF GAS TURBINE
COMPRESSOR EFFICIENCY × TURBINE EFFICIENCY
1′ Net output × 100 / Output of gas turbine at 1000 F before the turbine
2′ " " 1200 " " " "
3′ " " 1500 " " " "
4′ " " 2200 " " " "
THERMAL EFFICIENCY AT COUPLING—PER CENT
COMPRESSOR EFFICIENCY × TURBINE EFFICIENCY
1 Thermal efficiency at coupling of turbine at 1000 F
2 " " " " " " " 1200 "
3 " " " " " " " 1500 "
4 " " " " " " " 2200 "

FIG. 2 THERMAL EFFICIENCY AT COUPLING OF GAS TURBINE AS A FUNCTION OF THE OVER-ALL EFFICIENCY OF COMPRESSOR AND TURBINE

For different temperatures at the turbine inlet without recovery of exhaust heat

$$\text{Thermal efficiency} = \frac{\text{Heat equivalent of output at coupling}}{\text{Heat supplied by fuel}}$$

word of praise for their tenacity and the material sacrifices made by them in following up the idea.

The work done by Brown, Boveri & Co. in connection with the Holzwarth gas turbine resulted in the development of the Velox boiler,[1] whose principle is now well known to most engineers, but which nevertheless is referred to again because the experience gained with it led back to the combustion turbine. The Velox steam generator is a boiler fired under pressure, the pressure being produced by a compressor driven by a gas turbine, actuated by the exhaust gases of the boiler. Part of the pressure produced in the compressor is used to maintain high gas velocities in the heat-transmitting parts of the boiler, thus insuring high rates of heat transfer. The remainder of the pressure head is used to drive the gas turbine. This application of the gas turbine as an auxiliary rendered essential the creation of a compressor set having a high efficiency, otherwise the exhaust-gas turbine would be unable to develop the power required for driving the compressor, and the deficiency would have to be supplied by another source, which would have reflected seriously on the efficiency of the boiler.

The problem was solved by the development of a four- or five-stage reaction turbine and a ten- to twelve-stage axial compressor, the design taking into account the results of the latest research in the field of aerodynamics with the result that, in the majority of cases, not only is no supplementary driving energy required at full load but even excess power is available.

PRESENT STAGE OF DEVELOPMENT OF THE COMBUSTION TURBINE

The attainment of efficiencies of 70 per cent and more in large sets of this kind suggested that the possibilities of the combustion-turbine cycle for a prime mover without the use of steam be once more investigated. Fig. 2, which has already been used to explain why former designs failed to deliver any useful output, shows that with over-all efficiencies of 70–75 per cent it is possible to obtain the following net output efficiencies in the gas-turbine cycle:

Gas temperature at turbine inlet, F	Cycle efficiency, per cent
1000	15–18
1200	19–23
1500	22–26

The first question was: What temperature could safely be employed without harm to the gas-turbine blading? On the basis of experience obtained with a large number of Velox boilers, and from the operating records of hundreds of exhaust-gas turbines for Diesel-engine supercharging units, a temperature of 1000 F was considered absolutely safe for uncooled blades made of available heat-resisting steel, due allowance being made for inevitable temporary fluctuations of temperature during governing operations.

The efficiency corresponding to this temperature, relative to the output at the coupling and the net calorific value of the fuel, and assuming an over-all compressor and turbine efficiency of 73–75 per cent, readily obtainable with net outputs of 2000–8000 kw, could, according to the curves in Fig. 2, be expected to attain 17–18 per cent.

APPLICATIONS

The next question was: What use could there be for a turbine of this efficiency? In raising this question, it must be remembered that before high pressures were introduced, 18 per cent was considered a satisfactory efficiency for a steam turbine of this size, but with higher pressures and temperatures, regenerative heating of the condensate, air preheating, and all the dodges in use in modern power stations, it is now possible to attain for such outputs coupling efficiencies as high as 25 per cent. To attempt to compete with the modern base-load steam turbine would, therefore, be useless.

SUPERCHARGING IN CHEMICAL PROCESSES

The demand for hot compressed air in connection with the Houdry cracking process[2] created the first interesting field of application for the gas turbine. Many chemical processes are favorably affected by an increase in pressure, either by intensifying the action of catalysts or otherwise assisting the reaction, and resulting in an improvement in quality or an increase in quantity of the product, or by enabling smaller and therefore cheaper apparatus to be used. In many such processes, super-

[1] "The Velox Steam Generator—Its Possibilities as Applied to Land and Sea," by Adolphe Meyer, MECHANICAL ENGINEERING, 1935, vol. 57, p. 467.

[2] "Houdry Process," by E. Houdry, W. F. Burt, A. E. Pew, Jr., and W. A. Peters, Jr., *The Oil and Gas Journal*, 1938, vol. 37, p. 40.

charging is impossible in practice, owing to the cost of compressing the air, but if the gases resulting from the process can be expanded in a gas turbine, and the power thus produced is sufficient to drive the compressor, supercharging is in many cases both feasible and economical.

This applies to the Houdry cracking process, where the power generated by the exhaust gases in the gas turbine more than suffices for supplying that taken by the compressor, the excess being used for driving a generator coupled to the set through gearing. Although the pressure drop in the apparatus used for the cracking process results in the electrical energy obtained being considerably less than that which would be delivered by a pure gas turbine, the energy produced is sufficient to cover the power requirements of the cracking process, for which a Velox boiler supplies the necessary steam. The gas turbine has an output of 5300 kw, and the input to the compressor is 4400 kw, the excess of 900 kw being converted into electrical energy. The unit, which is shown in Figs. 3 and 4, has been in operation day and night for more than two years in the Marcus Hook Refinery of the Sun Oil Company, near Philadelphia. The experience gained with this gas turbine resulted in orders for 12 additional units, of which two are already running, one in Italy, and the other in Texas.

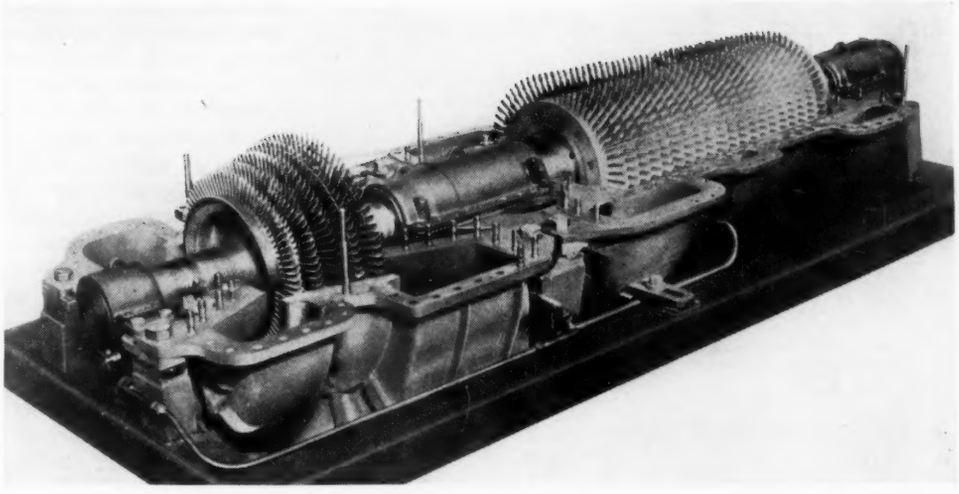


FIG. 4 GAS-TURBINE UNIT SHOWN IN FIG. 3 WITH TOP REMOVED

STAND-BY AND PEAK-LOAD PLANTS

Although the simple combustion turbine cannot yet compete with the modern steam plant for base-load purposes, it deserves serious consideration as a stand-by and peak-load unit, on account of its special advantages. It is of simple design, cheap, light, requires little space, and, last but not least, is not dependent on any water supply. This means that the foundations and buildings are cheap, and that the plant can be installed right at the point of consumption.

These advantages are of particular importance in the case of so-called bombproof emergency stations, such as are now frequently built to meet the power requirements of key industries in time of war, and for the maintenance of the essential services of towns (such as waterworks) which normally receive current over transmission lines, in the event of the power supply's being interrupted. An example of this type of plant is the 4000-kw set ordered for the city of Neuchatel a year ago. Fig. 5 illustrates the extraordinary simplicity of such a power station. The set operates on the principle of the diagram shown in Fig. 1. The only auxiliary plant is the separate small Diesel-driven alternator, which, in the event of a complete failure of power, serves to supply the starting motor of the gas turbine. Fig. 14 shows the set being tested at the plant of Brown, Boveri & Co. in Baden (Switzerland). The set is designed for operating at a temperature of 1000 F before the turbine, and with the pressure ratio of the blower amounting to about 4. As it is intended only for emergencies, air preheating was not adopted. The guaranteed thermal efficiency is 16 per cent.

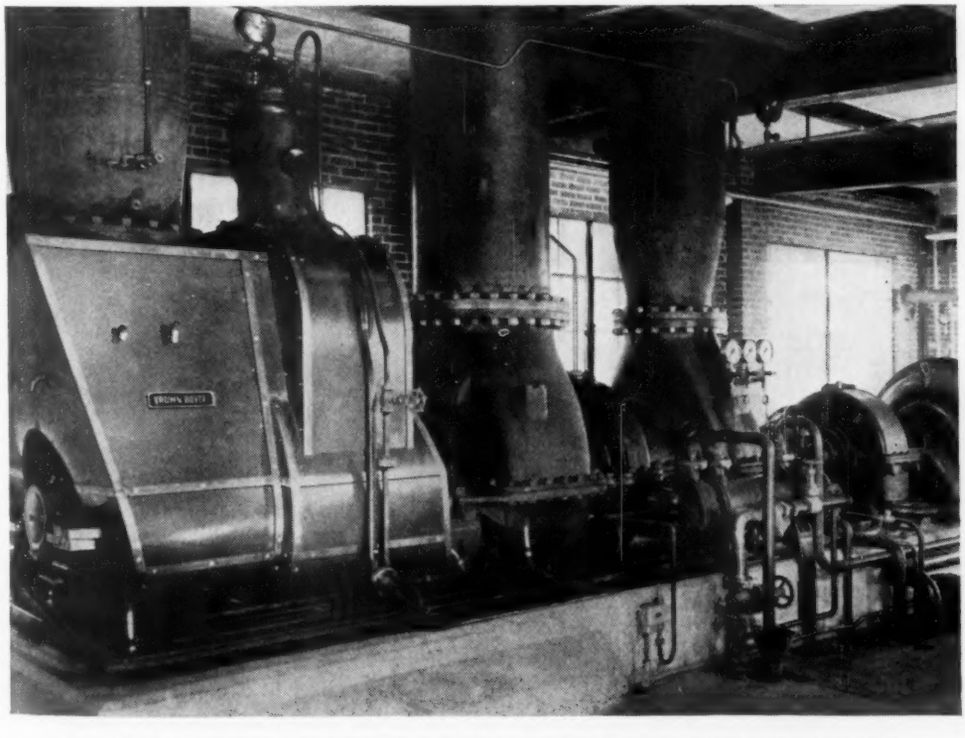


FIG. 3 GAS-TURBINE SUPERCHARGING PLANT FOR THE HOUDRY OIL-REFINING PROCESS
(Sun Oil Company, Marcus Hook, near Philadelphia, Pa.)

COMBUSTION-TURBINE LOCOMOTIVE

An interesting application of the gas turbine is the gas-turbine locomotive. It is well known that the efficiency of a

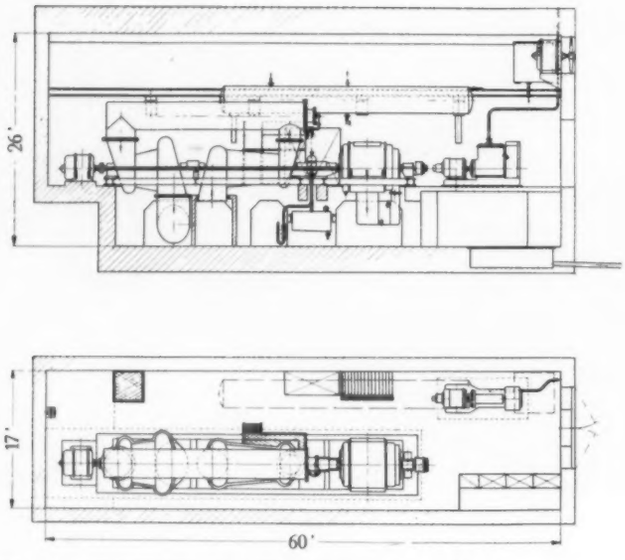


FIG. 5 BOMBPROOF GAS-TURBINE-DRIVEN 4000-KW STAND-BY PLANT FOR THE CITY OF NEUCHATEL

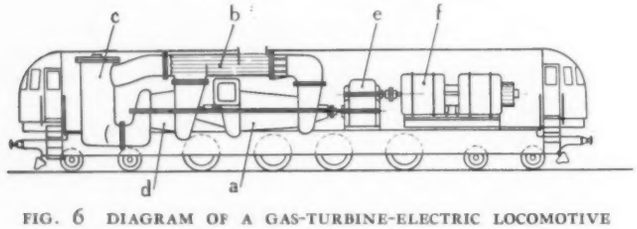
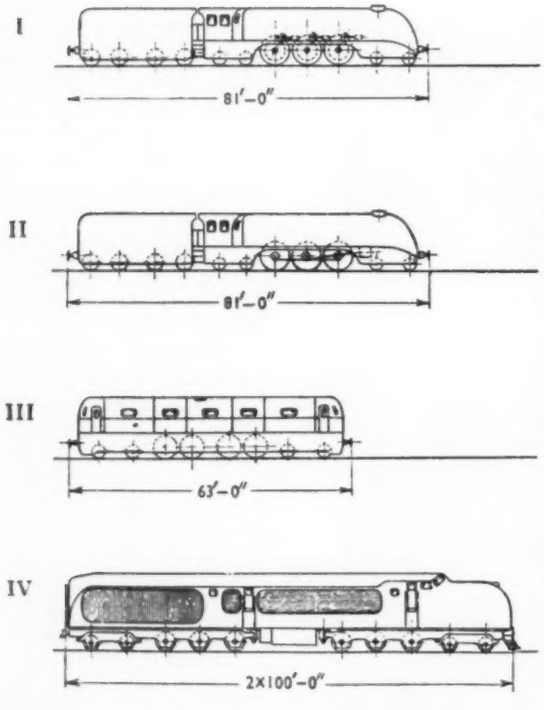


FIG. 6 DIAGRAM OF A GAS-TURBINE-ELECTRIC LOCOMOTIVE (*a*, compressor; *b*, heat exchanger; *c*, combustion chamber; *d*, gas turbine; *e*, gearbox; and *f*, electric generator.)

steam locomotive is only of the order of 8–12 per cent, the latter figure allowing for all improvements made in the course of the last few years. The gas turbine with its coupling efficiency of 17 to 20 per cent finds here a promising field of application, since it should be possible to obtain an efficiency of approximately 15 per cent with mechanical transmission, or approximately 14 per cent with electrical transmission. These efficiencies do not naturally allow for competition with the Diesel engine, but the difference between the fuel consumptions of the two machines is in many cases fully compensated by the difference in the costs of Diesel oil and fuel. Moreover, in many cases the possibility of getting more power from a given size of locomotive is of greater importance than the efficiency. Since about twice the output can be installed in a combustion-turbine locomotive than in a corresponding Diesel-engine locomotive, the former, in many cases, deserves due consideration from this point of view. Another advantage, compared with steam locomotives, is the fact that the gas-turbine locomotive needs no water, thus doing away with cleaning of boilers and interruptions of service resulting therefrom.

In the case of electrical transmission, only the gas-turbine part is new, the generators, motors, and switchgear being adopted from the Diesel-electric locomotive without modification. The gas turbine which drives the generator through gearing can always be operated at the most suitable speed for the compressor, so that the engine gives a high efficiency at all speeds and loads. Such a locomotive is, of course, heavier and more expensive than one with mechanical transmissions, but since it will be necessary to provide, in addition to the forward turbines, reverse turbines or corresponding reversing gears, difficulties may have to be overcome, especially in case of high outputs. Fig. 6 shows a gas-turbine locomotive with electrical transmission. Fig. 7 compares different designs and sizes of locomotives.



Technical data	High-pressure locomotive with reciprocating engine	Standard locomotive with reciprocating engine	Gas-turbine locomotive with electrical transmission	High-pressure locomotive with condensing plant and electrical transmission
Locomotive	I	II	III	IV
Railway system	North	North	Project	Union Pacific Railroad
Type	2 C_0 2	2 C 2	2 D_0 2	2 C_0–C_0 2
Builder	Swiss Locomotive and Machine Works, Winterthur, and Alsacienne	Alsacienne	Brown, Boveri	General Electric Company
Power at rim of wheel, h.p.	3,000	3,000	3,000	(2) × 2,500
Thermal efficiency at rim of wheel, per cent	12	10	17	14·5
Service weight with tender, tons	194	180	135	(2) × 234
Speed, m.p.h. .	75	75	85	100
Fuel	Coal	Coal	Fuel oil	Fuel oil
Length including tender, feet	81	81	63	(2) × 100

FIG. 7 GAS-TURBINE LOCOMOTIVE COMPARED WITH STEAM AND STEAM-ELECTRIC LOCOMOTIVES

The Swiss Federal Railways recently placed an order with Brown, Boveri & Co. for a gas-turbine-driven locomotive designed for 2200 bhp at the generator coupling or approximately 1900 bhp at the tread of the driving wheels. This locomotive, of the 1A–B–A1 type, has a maximum speed of 75 km per hr. The locomotive is to have a heat exchanger of about 3000 sq ft heating surface, which will return part of the heat of the exhaust gases of the gas turbine to the compressed air. With a working weight of approximately 95 tons, the fuel-oil consumption will be 0.88 lb per hp-hr. The power required to start the combustion engine is to be supplied by a battery.

BLAST-FURNACE PLANTS

Interesting possibilities for the application of the gas-turbine drive are offered by blast-furnace plants, especially when the air supply for the blast furnace and its heating are combined with the operation of the combustion turbine by using the same compressor and, also, a common combustion chamber for both purposes. This combination becomes particularly interesting when the air heaters are fired under pressure, in which case their dimensions can be considerably reduced, as shown in Fig. 8, which shows in the top left-hand corner a comparison between the dimensions of ordinary air heaters and supercharged ones; on the right-hand side are shown the air heaters with the accessory machines.

The Mannheim plant of Brown, Boveri & Co. have at present under construction two gas-turbine-driven blast-furnace blowers. Apart from the innovation of the gas-turbine drive, these blowers are noteworthy for the fact that they also supply the air required by the gas turbine. They are of the axial-flow type designed for a volume of air three times as great as that required by the blast furnace. This large increase in delivery volume not only insures very high compressor efficiencies, but also facilitates governing, since even considerable fluctuations in the blast requirements result in comparatively small variations in the total delivery volume of the compressor. The maximum air requirements of the blast furnace for each set amount to 59,000 cu ft per min or 260,000 lb per hr, while the blower delivers 770,000 lb per hr; two thirds of the air goes to the gas turbine; 44,000 lb per hr is used as combustion air, and the rest as cooling air. The air pressure is 17 lb per sq in. and the fuel is blast-furnace gas compressed by a special blower coupled to the gas turbine through gearing.

The gas turbine is a four-stage-reaction type and delivers 9450 kw at 2600 rpm. The normal temperature of the driving gas is 1000 F at full load and the expansion ratio approximately 2.0. The blower is of the axial-flow

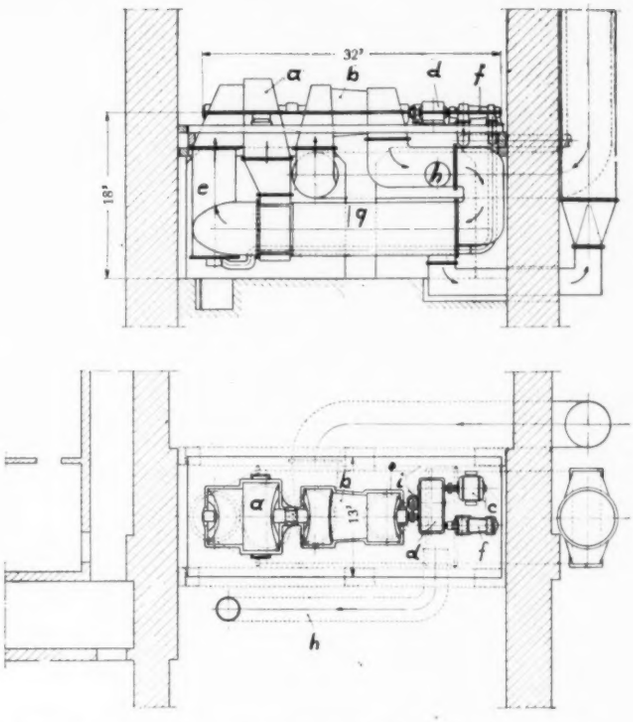


FIG. 9 GAS-TURBINE-DRIVEN 35,000 CFM BLAST-AIR PLANT

(*a*, gas turbine; *b*, axial blower; *c*, starting motor; *d*, gear; *e*, combustion chamber; *f*, gas blower; *g*, heat exchanger; *h*, blast-air outlet; and *i*, lubricating and governing oil pump.)

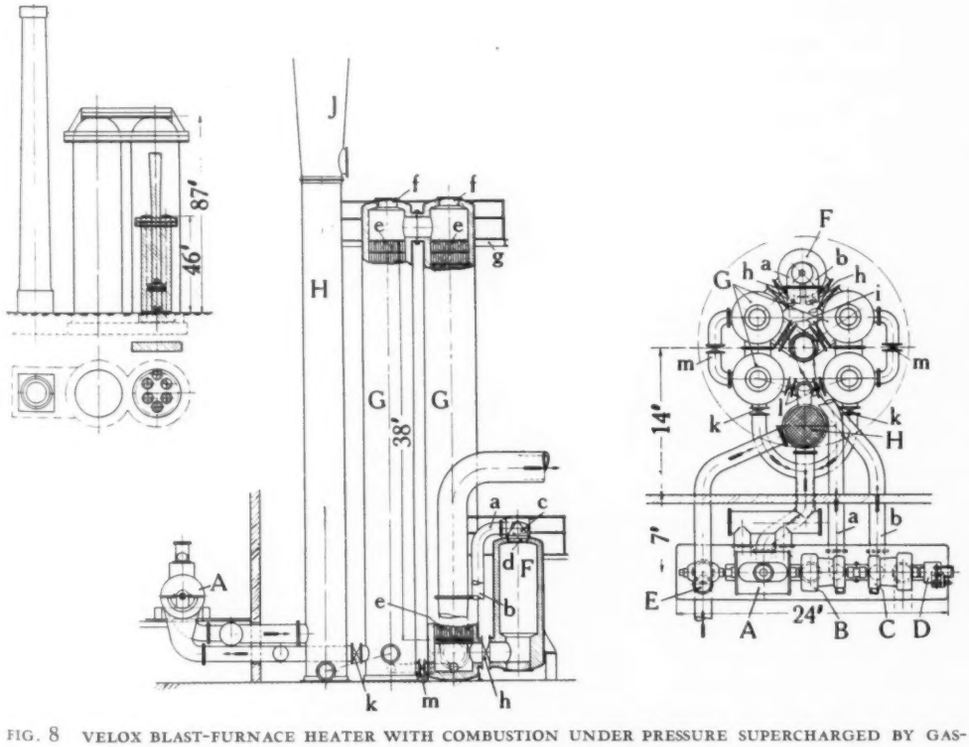


FIG. 8 VELOX BLAST-FURNACE HEATER WITH COMBUSTION UNDER PRESSURE SUPERCHARGED BY GAS-TURBINE-DRIVEN AIR AND GAS COMPRESSORS

(Output 25,000 cu ft per min; blast temperature 1650 F; combustion pressure 22 lb per sq in.; and duration of cycle 10 minutes. *Supercharging set: A*, gas turbine; *B*, combustion-air compressor; *C*, gas compressor; *D*, auxiliary motor; and *E*, booster blower for the blast air. *Blast heater: F*, combustion chamber, *a*, combustion-air supply; *b*, gas supply; *c*, mixing chamber; *d*, burner; *e*, refractory; *G*, regenerators; *H*, air preheater for the blast (recovery); and *J*, stack. *Changeover valve gear: h*, hot gases; *j*, hot blast; *k*, cold gases; *l*, cold blast; and *m*, by-pass for temperature regulator.)

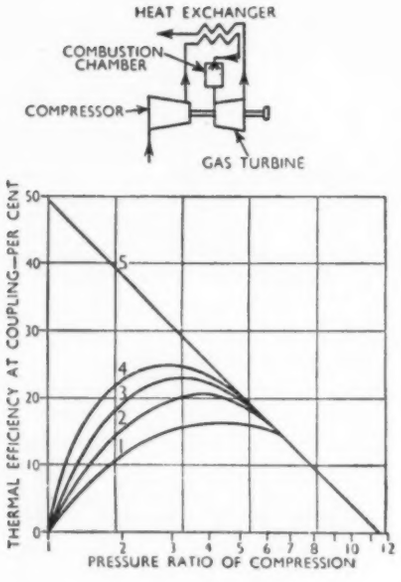


FIG. 10 EFFICIENCY AT COUPLING OF 2000-KW COMBUSTION TURBINE

(With temperature of 1000 F at the turbine inlet and air preheating by exhaust gases with different sizes of preheater.
Surface of heat exchanger for 2000 kw

Curve 1	0 sq ft
Curve 2	5,000 sq ft
Curve 3	15,000 sq ft
Curve 4	30,000 sq ft
Curve 5	∞ sq ft (theoretical)

Temperature before turbine, 1000 F; temperature of intake air, 68 F; compression without cooling.)

type and requires 8700 kw at 2600 rpm. The ratio of compression is 2.2 and the final air temperature approximately 220 F at an intake temperature of about 70 F.

The blast-furnace-gas blower, designed for 8500 rpm, is capable of delivering a maximum volume of 42,000 lb per hr of blast-furnace gas, though only about 33,000 lb per hr are required at full load. At an intake temperature of 120 F the delivery temperature is around 360 F and regulation of the volume is achieved by a by-pass. This blower is the axial-flow type with a maximum rating of 750 kw. For starting, a direct-coupled 170-kw electric motor brings the speed of the blower up to 1000 rpm, which is then automatically disconnected and driven by the gas turbine.

The temperature of the exhaust leaving the turbine is approximately 700 F. To recover part of the exhaust heat, a heat exchanger having a heating surface of about 40,000 sq ft preheats the air, which leaves the compressor, from 210 to 660 F. The thermal efficiency of the plant is expected to be approximately 18.7 per cent and represents the ratio of the heat value of the useful air (blast-furnace air) compressed adiabatically from atmospheric pressure at an inlet temperature of 70 F and 17 lb per sq in. to the heat value of the fuel supplied. However, if the efficiency is a function of the shaft output of the blast blower (if it were a separate unit and only designed to supply the blast), it would be 22.7 per cent. These efficiencies are obtained with a full-load efficiency of the gas turbine of 87 per cent, and of the compressor of 83 per cent.

A noteworthy simplification and improvement in supplying air for blast furnaces by means of gas turbines is obtained if not only the blast and air for the gas turbine are supplied by the same compressor, but also the same combustion chamber is used for the heating of the blast and the production of the gas. The highly compressed heating gases produced in the common combustion chamber heat the top stage of the blast heater first and then flow from there to the gas turbine. Since the temperature of these driving gases is usually too high, they are mixed with cooler air before they enter the gas turbine After having been expanded and used to drive the gas turbine, the gases flow into the lower stage of the blast heater, which also forms the preheater for the combustion air and the blast furnace gas consumed in the combustion chamber. Consequently the combustion air, cooling air, and the blast are supplied by one blower. Since the heating gases of the upper stage of the blast heater are also the driving gases of the gas turbine, their pressure is the same or may be even higher than the blast pressure. The upper stage of the blast heater therefore must be designed as a "pressure-fired" or "pressure-charged" blast heater. On account of the greater density of the heating gases, the considerably greater velocity of flow generally adopted, and the high specific transmission resulting therefrom, its heating surfaces and dimensions are smaller than those of the regular type.

Also in process is a gas turbine for a plant which later will be equipped with pressure-fired blast heaters and a common combustion chamber arranged as described above. The compressor of this plant is capable of delivering 440,000 lb of air per hour,

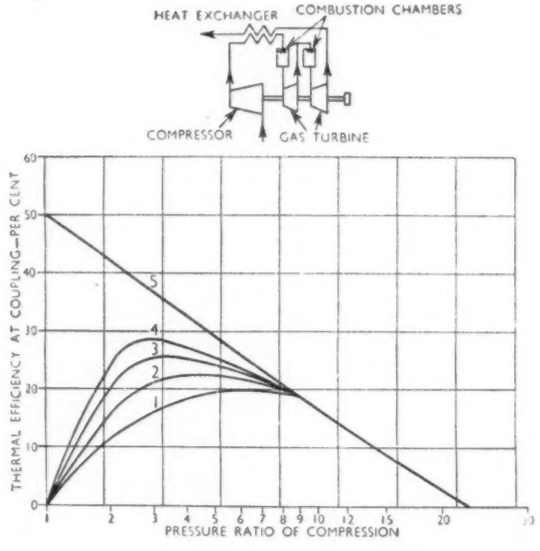


FIG. 11 EFFICIENCY AT COUPLING OF A 2000-KW COMBUSTION TURBINE

(With a temperature of 1000 F at the turbine inlet and air preheating by exhaust gases with different sizes of preheater, and preheating of the gases to the initial temperature between two stages.
Surface of heat exchanger for 2000 kw:

Curve 1	0 sq ft
Curve 2	5,000 sq ft
Curve 3	15,000 sq ft
Curve 4	30,000 sq ft
Curve 5	∞ sq ft (theoretical)

Temperature before turbine, 1000 F; temperature of intake air, 68 F; compression without cooling; turbine efficiency, 86 per cent; and compressor efficiency, 83 per cent.)

154,000 lb or 35,000 cfm of which is used as blast, while 286,000 lb per hr is supplied to the gas turbine. The pressure at the compressor is 17 lb per sq in., and before the gas turbine 16 lb per sq in., and the temperature of the driving gas is 1000 F. The gas turbine develops 5440 kw, the compressor requires 4980 kw, and 460 kw is consumed by the blast-furnace compressor and gearing. The speed of the gas turbine and blower is 3300 rpm and that of the blast-furnace-gas compressor 9600 rpm. The gases leave the turbine at 780 F and flow into a pre-

heater which heats the blast-furnace gas and the combustion and mixing air to 680 F. It is expected that the efficiency of the plant, shown in Fig. 9, with reference to the adiabatic compression of air used for the furnace, will be 18 per cent. The plant will be equipped at first with an ordinary combustion chamber used exclusively for producing the driving gas. It is intended later to couple it to a pressure-fired blast heater. The temperature of the gas before the gas turbine will then have to be increased to 1100 F, and the pressure of the compressor to 26 lb per sq in.

IMPROVEMENTS IN THE CYCLE

The first two applications already referred to correspond to the design shown in Fig. 1. An important improvement is attained by the utilization of the heat of the exhaust gases of the turbine to preheat the compressed air as applied in the gas-turbine locomotive and the blast-furnace plant. In Fig. 10 the coupling efficiencies of the gas-turbine set, with heat exchangers of different sizes for an output of 2000 kw, and a turbine admission temperature of 1000 F, are plotted against the pressure ratio of the compressor. It is seen from these curves that the recovery of the heat of the exhaust gases in a heat exchanger of 5000 sq ft raises the cycle efficiency from 16.5 to 21 per cent, i.e., brings about an improvement of 27 per cent.

A further improvement can be achieved by dividing up the gas turbine into several cylinders and reheating the gas between the cylinders to the initial temperature, as shown in Fig. 11, which is for a 2000-kw unit operating with an admission temperature of 1000 F and one intermediate-reheat stage. As can be seen from this diagram, it is thus possible to obtain an efficiency of 19 per cent without preheating the combustion air, and 22.5 per cent with the previously mentioned 5000-sq ft preheater. The number of reheating stages is limited by the increased cost of the plant, as well as by the pressure drop in the piping and combustion chambers.

Another innovation which improves the efficiency at fractional loads, but not at full load, can be obtained by using two turbines, one driving the compressor only without giving any power, and the other supplying only power. The efficiencies of the single-shaft arrangement and a two-shaft arrangement, for a unit of 2000 kw, each having an air preheater of 7500 sq ft and operating with an admission temperature of 1000 F, are compared in Fig. 12. The improvement at fractional loads takes place because the turbine driving the compressor can always be operated at the most suitable speed for the compressor, independently of the speed of the turbine supplying the useful power.

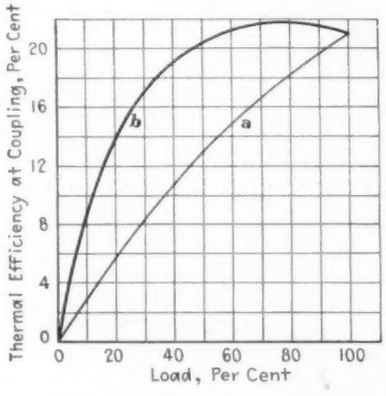


FIG. 12 THERMAL EFFICIENCY AT COUPLING AS A FUNCTION OF THE LOAD

(*a*, thermal efficiency without recovery, single-shaft arrangement with one turbine; and *b*, thermal efficiency with recovery, two-shaft arrangement with two turbines, one driving the compressor and the other driving the generator. Temperature before turbine, 1000 F; surface of heat exchanger, 5000 sq ft for 2000 kw.)

PROPOSED APPLICATION TO SHIP PROPULSION

A promising field of application for the combustion turbine is to be found in the propulsion of ships. Although competition with modern geared turbine plants cannot yet be contemplated, the question of placing 2000–4000 hp combustion turbines instead of reciprocating engines on oil-fired ships already deserves full investigation by interested parties, since efficiencies over 20 per cent can be obtained with a combustion-turbine plant through utilization of the heat of the exhaust gases for preheating the air, which means an increase of approximately 20 per cent on those attained with reciprocating engines.

The prospects for merchant ships will depend upon the conditions applying, and each case must be examined individually. A very different state of affairs prevails, however, in the case of warships, and, in particular, torpedo boats or destroyers, which are usually driven by steam turbines. Here the drive is a compromise, since the top speed entails outputs ten or even twenty times that required at normal cruising speed. Consequently, the steam and oil consumptions at both the top and cruising speeds differ considerably from those customary in the operation of stationary plants. The efficiency of such a marine turbine plant at full speed is approximately 14–18 per cent, i.e., of the order of that which can be obtained with a gas-turbine plant without preheating the combustion air. At cruising speed the efficiency may be even as low as 11–14 per cent. There is, therefore, no reason why a simple form of gas turbine should not be considered, in view of the fact that the average oil consumption over the whole speed range of the ship would be equal to the average of a steam drive. If, however, the many advantages afforded by the gas-turbine drive over the steam-turbine drive are taken into account, even a slightly higher fuel-oil consumption could be accepted.

These advantages are:

1 The great simplification of the plant, brought about by the omission of the boiler with its feedwater evaporating plant.

2 The reduced vulnerability when in action, due to the absence of large volumes of water and steam at high temperatures and pressures stored in boilers and steam pipes.

3 The simplification due to the omission of the condensing plant with all its auxiliaries, corrosion problems, and other troubles.

4 The rapidity with which the gas-turbine plant can be brought into service, only as many seconds being required as minutes are needed for a boiler installation.

5 The fact that the plant stops and becomes cool within a few seconds of cutting off the fuel supply, because the stored energy is quickly absorbed by the compressor which pumps cold air through, and thus cools the combustion chamber and gas turbine.

PROPOSED APPLICATION IN WIND TUNNELS

A comparatively small but interesting field of application is the drive of wind-tunnel blowers for testing airplane forms. Such drives, which require a considerable amount of power (up to 5000 hp) for testing purposes, and, usually for short periods only, are very unfavored consumers of current, and are charged for energy at high rates; moreover, the periods during which power can be taken are frequently restricted.

PROPOSED APPLICATION IN A COMBINED GAS-TURBINE AND STEAM PLANT

The more important fields of application for which gas-turbine plants have already been supplied or proposed have been

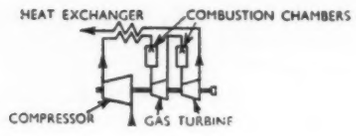
enumerated. The potentialities of this type of prime mover are, however, far from exhausted by this account. Mention may be made of at least one additional field, namely, the combination of the combustion turbine with the utilization of the heat of the exhaust gases for producing steam in exhaust-gas boilers together with, or instead of, preheating the combustion air. In many cases where there is a demand for steam in addition to energy, the combustion turbine with an exhaust-gas boiler is more economical and cheaper than a high-pressure steam plant with back-pressure or extraction turbines.

A GLIMPSE INTO THE FUTURE

Fig. 2 shows that an increase in the over-all efficiency of compressor and turbine from 70 to 75 per cent raises the cycle efficiency from 15 to 18 per cent, representing an improvement of 20 per cent. Every 1 per cent increase in the efficiency of the compressor or the turbine means, therefore, an improvement of 4 per cent in the cycle efficiency. Here, then, is a field in which much progress may be expected.

Fig. 2 also shows the improvement accruing from the use of higher temperatures at the gas-turbine inlet. Such temperatures will be admissible either when materials of a correspondingly high creep strength are available, or when some means is devised for protecting the blading of the materials now used against the effects of such high temperatures. It can be seen from the curves that with an over-all compressor and turbine efficiency of 76 per cent, increasing the temperature at the turbine inlet from 1000 to 1200 F, raises the cycle efficiency from 18 to 23 per cent, representing an improvement of 28 per cent. Fig. 13, which gives the cycle efficiency for a two-cylinder 2000-kw gas turbine with intermediate reheating and a temperature of 1200 F, indicates that the efficiency reaches 24 per cent without air preheating, 26.5 per cent with a preheater of 5000-sq ft heating surface, and 33 per cent with a preheater of 30,000-sq ft heating surface.

The prospects of the gas turbine, if it is possible—as the author believes it is—to raise the temperature in the near future to 1200 F, can be readily appreciated. This belief is based upon the experience obtained with a number of Deisel-engine supercharging units which have been in operation for a considerable time at temperatures approaching this value, and on tests with relatively rudimentary cooling arrangements,



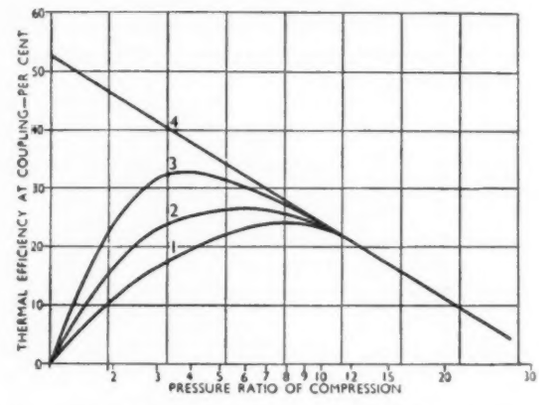


FIG. 13 EFFICIENCY AT COUPLING OF A 2000-KW COMBUSTION TURBINE

(Temperature, 1200 F at turbine inlet; preheating of the air by exhaust gases with different sizes of preheaters; reheating of the gases to the initial temperature between two stages.

Surface of heat exchanger for 2000 kw:

Curve 1	0 sq ft
Curve 2	5,000 sq ft
Curve 3	30,000 sq ft
Curve 4	∞ sq ft (theoretical)

Temperature before turbine, 1200 F; temperature of intake air, 68 F; turbine efficiency, 86 per cent; and compressor efficiency, 83 per cent.)

which show that temperatures around 1800 F are in the realm of possibility.

The picture which this paper has attempted to convey, of the present state and future of the combustion turbine, is necessarily incomplete, but it will serve to show that the subject is a promising one, full of interesting possibilities and the fulfillment of a dream long cherished by engineers.

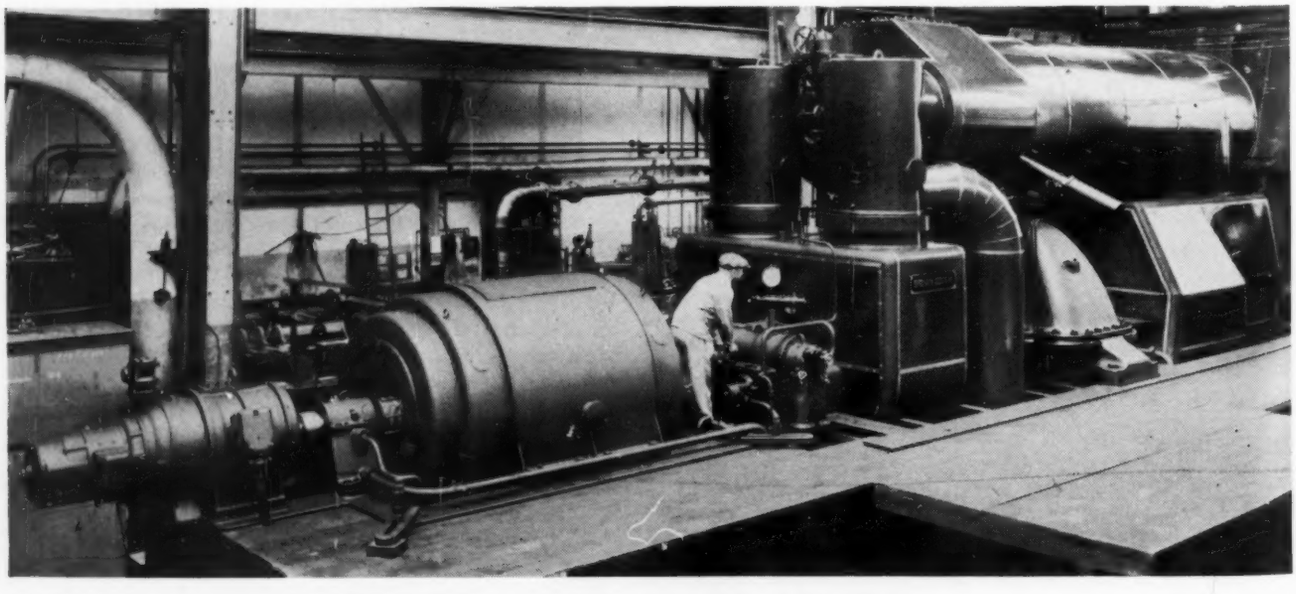


FIG. 14 COMBUSTION TURBINE SHOWN IN FIG. 5 ON TEST

SOCIAL RESPONSIBILITY *of the* ENGINEER

By ROBERT E. DOHERTY

PRESIDENT, CARNEGIE INSTITUTE OF TECHNOLOGY, PITTSBURGH, PA.

WHETHER engineers should assume a larger measure of social responsibility has been debated extensively during the last decade with practical results that are not impressive, yet there appears to be significant crystallization of professed opinion. While the view still lingers here and there that the engineer should stick to his technical knitting, letting other professional men worry about the social consequences of his work, there is nevertheless a pervasive and growing opinion that he should play a more active part in the social realm and that his educational preparation should take this aim into account. However, the extent of the discussion and of apparent agreement upon this point is out of all proportion to the practical results as measured either by active participation or by changes in educational programs looking to participation. Progress seems to be stymied biologically; after professional maturity we seem to exhibit a certain elasticity of professed view but tend nevertheless to cling tenaciously to established habits. Not having participated, we don't start. Thus as a profession of engineers and educators we seem to agree upon principle, and more or less let it go at that.

MUCH TALK BUT LITTLE ACTION

There is significant evidence of this attitude. While a few national engineering societies appear interested in social values that might come from united effort, others seem indifferent. Witness the precarious status of the American Engineering Council, which is withering from lack of support; yet it represents the only national medium through which the engineering profession as a whole can serve national welfare as well as its own interests. And it is my understanding that the Council has done a good job within its means. Another example is the Engineers' Council for Professional Development. This is the only organization that is constituted by proper representation to lift the engineering profession on all fronts to the level that it deserves and that we all wish for. And it has made measurable beginnings in four important directions, as presumably you all know. Yet the reservations with which some engineering societies enter it indicate a significant attitude of self-sufficiency. Naturally it is not for me to question in the least their full right to any attitude they wish to assume. I am merely citing it as evidence to my point that the engineering profession, although tending to agree that the engineer's station in society should be higher and his responsibility greater, has not yet reached the point of doing much about it. Neither has the teaching profession, as a glance at engineering curricula will indicate. A few show some revision toward the end of greater social and humane understanding, but by and large the portion of the curriculum assigned to this end is distressingly meager. Status quo tends to persist.

Meantime national life proceeds more and more precariously. While we tire of hearing tales of woe, the ugly fact is that strife and confusion characterize the American scene. Pressure groups fight for selfish advantage; political demigods try to out-do each other in leading raids upon the public treasury; labor fights with employers and with itself; and government and business are at loggerheads. Although Theodore Roosevelt invented the "square deal," Woodrow Wilson the "new freedom," Herbert Hoover the "new era," and Franklin Roosevelt the "new deal," nevertheless after a generation of political discovery and invention, the American people have become more baffled than ever in their efforts to incorporate the vast discoveries and inventions of science into their scheme of living so that they might realize in peaceful, prosperous, and happy lives, the limitless potentialities of these intellectual and material achievements. Individuals, groups, classes, and nations quarrel over the division of limited production instead of cooperating to provide an abundance for all; and they wantonly squander existing values and mortgage those of the future. Youth is discouraged; businessmen are confounded; trustees of great endowments don't know what to do; men without funds and men without work don't know what to do; nobody knows what to do!

What is the outlook? One's optimism is, I realize, likely to be adversely conditioned by immediate circumstances such as those I have just mentioned. On the other hand, the mere exhibition of optimism unfortunately is not very fruitful in an analysis; and whistling in the dark will not stop the lurking gangster. So at least for the next few minutes I may appear to assume the role of the pessimist, for I must confess that within my limited view there is little promise of long-range social felicity unless I postulate some new element that is not yet manifest in the body politic.

IS SOCIAL CONFLICT NECESSARY?

History is not reassuring. In his article "Are Revolutions Necessary," historian Guy Stanton Ford, now President of the University of Minnesota, said this: "To the question 'Must short-time and long-time changes end always in conflict and violence?' the historian can only answer with certainty that the clash between beneficiaries of the existing order and exasperated advocates of change has always so ended. Each time, resistance to modest reform is blind to the wisdom of concession and the necessity of change. If concessions are made, they come too late. The demands have risen and the price of peace is again too high, only to become again too cheap. The reactionary breeds the radical among reformers, the approaching conflict falls under the leadership of these two opposing extremes, and the conflict follows. The process has been repeated so often in so many fields that it appears inevitable and, historically speaking, necessary.

"Have we before us any hope that mankind has, after all these centuries, learned a way to make, without violent dislocation, the necessary readjustments in his relations to his material environment and his fellow man?"

To President Ford's answer that there may be hope if we can learn to be tolerant and maintain the sanctity of free press, free

An address at the Annual Meeting of the Society for the Promotion of Engineering Education, State College, Pa., June 19–23, 1939.

speech, and the scholar's immunity to pursue truth, I would add two other essentials: (1) That we learn to make practical use of a new power within our reach that the generations of history did not have—the power of reasonable prediction that may come from the scientific method if it be applied to social and economic problems with the same intelligence as it has been applied during the last few generations to physical problems; and (2) that in our democracy we find a way to accomplish widespread social interest and understanding among professional men. Tolerance is necessary, but understanding there must be also; the issues even in their simplest forms become too much for most untrained, uninformed minds. There must be here and there among the masses cultivated intellects that can understand and give support to informed decision. And there must be in the councils of the state and nation not merely professional expertness, but expertness fortified by broad social understanding and a willingness to cooperate.

I am clear that there is no political panacea for our woes. Many feel that a less severe attitude by the national administration would be helpful, but I am confident that neither such an attitude nor a change of administration would solve the problem, because at bottom it is not political. It existed before the present administration came to office and will continue when a new administration comes to power. Social forces of the character and magnitude of those which now press us are not to be controlled by the fickle furor of partisan politics. Oscillating like a mighty, sweeping pendulum, they swing us back and forth with ever-increasing violence between glut and poverty. And it will take more than political oratory to deal with the situation.

The job of professional statesmanship is to see that an end be put to the political hand-to-mouth method of dealing with social problems, and that these be recognized and attacked early enough and intelligently enough so that people's minds may become *gradually* accustomed to the new ideas involved. Then perhaps necessary change may be effected without violence and chaos. It is my purpose during the next few minutes to outline how I think engineers should enter this situation, why they should assume greater social responsibility, what it might be, and how their active interest might be won.

COMPETENCE NEEDED IN A DEMOCRACY

The fundamental ground on which I believe engineers should assume greater social responsibility is the fact that, after all, we live in a democracy. I have found it difficult to elicit interest in this idea because there is a widespread inclination to regard allusions to democracy and competent citizenship as sentimental vapor—as something nice to talk about, especially on flag day, but not in serious meetings of the kind I take this to be. Such matters are left largely to primary and secondary schools. But I do hope we can set aside such insidious prejudices if we have them, because there is involved here a deeper significance than momentary patriotic fervor; a greater responsibility, especially for professionalmen, than merely voting, accepting majority rule, and understanding the machinery of government. Our question transcends these; it strikes at the heart of the matter. Lifted out of the welter of confusing elements, the question we must answer is whether in our thinking and planning in connection with the future of engineering and engineering education in this country we are ready sincerely to accept as a philosophical basis the principle of democracy. If we are not, then I recommend that we prepare our exit. If we are, then we are obliged, if we be rational, to accept the implications.

These are simple. If the people or their representatives are to settle questions of state—and national concern—then certainly they must be competent to do so or the whole system becomes a farce. Indeed it appears already to be approaching this. Issues have become too complex for the masses to understand; indeed they have become too complex for those whose business it is to understand and deal with them. By the very nature of the case, therefore, if we accept the theory of democracy we must accept also the proposition that there should be available to government at all its levels intelligent understanding and competence to deal with problems of statesmanship that have to be solved.

Such competence in a democracy cannot be confined to a capacity for balancing the relative advantages of different courses of action and approving that course which appears best; it must include as well competence in the use of present day facilities for making these alternatives understandable to the voters by whom basic issues are decided. This requirement carries the problem into a field which scientifically trained men are frequently reluctant to enter—that of publicity and propaganda. But unless educated citizens are prepared to make themselves competent in this field for the benefit of society at large, their efforts, no matter how wisely conceived, will be overwhelmed by the propaganda of pressure groups who pursue selfish interests and who frequently have the skill to clothe these interests in the robes of patriotism and public welfare. Educated citizens must learn to explain social problems as well as to solve them.

To my mind, therefore, acceptance of the principle of democracy implies a new emphasis in education and a new sense of responsibility of citizenship on the part of professional men, not only as individuals but also as organized professional groups. It seems to me necessary that there be a pervasive infiltration, among the citizenry, of professional people who will have become socially literate and who will feel the responsibility that goes with advantage and privilege; and further that professional groups hold constantly and pre-eminently in view their status as organic units of a democracy now under stress and their responsibility to help save it for future generations.

Then there are other grounds, I contend, why engineers have an especial responsibility. In proposing these grounds, however, I hope I need not disclaim the supposition that engineers are self-righteous and endowed with special intellectual gifts and that therefore as a professional group they are the hope of the world. There are, however, two special facts regarding engineers that place them in a unique position, and I need do no more than mention them to this audience. One is that the very nature of their professional work affects social organization. For example, in industrial management where they hold forth, social and economic problems loom large. Moreover, their technical achievements are associated with the origin of basic social problems—for instance, immediate technological unemployment and the rapid fundamental alteration of the physical environment of society. Thus being the authors of, and therefore intimately understanding, the causes themselves, they should be in an advantageous position to learn how to control the effects.

ENGINEER'S METHOD IS EFFECTIVE

The other special fact is the effectiveness of the engineer's method. The care and objectivity with which he approaches a problem, his insistence upon understanding its elements as far as may be practicable before deciding upon plans, the impartiality of his decisions, the firmness of his execution—these are certainly something to be desired in social and economic affairs. The discipline of dealing with facts and principles that demonstrate themselves—sometimes publicly, if the bridge fails—has been widely and justly praised as a commendable attribute of the engineer's calling. So I am only repeating a

commonplace when I propose that there is undoubtedly something in the engineering method, the scientific method, that is wanting in many social procedures and that could with great profit be exercised there. But believing this, I yet know that it would be putting the doctrine of transfer of ability to severe stress to move the engineer with his present knowledge and method over into the social realm without an appropriate leavening of his mind with humane appreciation and social understanding. But with this, I am confident that his method would greatly reinforce the attack upon those social problems that are related to his fields, or are a part of them.

Thus his method and the social implications of his work are cogent reasons for his assuming greater social responsibility; and added to these is the fundamental proposition that responsibility is doubly implied in democracy—through his citizenship and his organized professional connections.

WHAT IS ENGINEER'S RESPONSIBILITY?

What might that responsibility be? In what ways might the engineer become socially more serviceable? I have already indicated this in general terms. To be more specific brings one close to the realm of speculation. What, for instance, might the engineer actually do as an educated citizen? Just what every other educated citizen should do: Keep informed regarding public issues, arrive at intelligent convictions, and give these as forceful expression as possible by such means as may be at his command. These means obviously include active cooperation with other citizens in the promotion of causes which appear sound; helping the masses understand; and taking a much more extensive hand in public service in his local community, or in state or national affairs.

Moreover, engineers are increasingly forced to assume social responsibilities incident to their professional service. Managers and promoters of new technical undertakings must, willy-nilly, take account of the social consequences of alternative approaches to problems which have to be solved, and because the social and the technical aspects of these problems are interwoven, the two must be handled concurrently. The engineer who is blind to the social implications of his work is a less efficient engineer when social problems are involved than the one whose analysis includes necessary social factors, because whether we like it or not these have become a part of engineering activity. The engineer's achievements in management on the material, technical, and economic sides have been magnificent, and he has frequently rendered notable service on the social side of his undertakings. In other cases, however, social ills, avoidable and unavoidable, have accompanied engineering progress, and it has become clear that the engineer has an important responsibility in helping to ameliorate these conditions. In the midst of management he certainly is in a most favorable location to do so.

And finally as a member of organized engineering groups he might together with his colleagues exert telling influence upon important national problems. Most certainly in those which involve engineering elements he should have a strong voice in the forming of policy as well as the responsibility for technical plans. And more general still, he should be represented on equal footing with other professions on commissions and councils of government that might work out intelligent recommendations regarding long-range policy on which legislative bodies or administrations might act. In other words, wherever intelligent group procedure is required in connection with the problems of the democracy, the engineer should be represented.

But what can be said of the view one occasionally meets that the engineer's business is engineering, and that social and economic matters should be left to the social scientist? There is no berth in my mind for this opinion for two reasons: It stretches too far the theory of the division of labor, and it contravenes the principle of democracy. Experience proves division of labor to be sound in the building of a gun or automobile, but not where the business is settling what human relationships and human interests should be. It is one thing to have the several operations of shaping and assembling material parts done independently by different individuals according to an organized plan, and quite another to try to make the general plan itself by that method. And this is what we are discussing. Of course we should say that the strictly technical business of the social scientist should be done by him, of the engineer by the engineer, and of every other profession by that profession. But there are two things we must not do. We must not try to bound professional fields by straight lines when the boundaries are inherently irregular zones; rather we must articulate effectively those protruding areas at the boundary that should extend continuously from one field to another so that the whole pattern might represent an integrated, organic, social unit. And secondly, we must not confuse expertness in a particular field with qualification for forming general judgments as to social policy and plan. The medical profession should not itself decide whether we should have socialized medicine, but it should submit to a representative professional body the technical implications of such a policy; the legal profession should not itself decide upon laws, but certainly should deal with the technical business involved in their preparation and interpretation; the engineering profession should not itself decide whether we should have T.V.A., but certainly should make and interpret the results of its calculations; and the social scientist should not decide whether we should have a Federal Housing Authority, but should obviously make and submit his technical findings in relation thereto. Each profession must of course be responsible for technical expertness, and up to this point the theory of the division of labor is applicable; but no profession can be depended upon alone for judgments that involve interests and factors extending beyond its purview. And since there is not a superprofession—for most of us do not accord to social scientists this distinction—to which can be assigned the job of forming over-all judgments and framing recommendations of wise policy and plan, the theory of the division of labor is found wanting at that point. Anyway, in a democracy who is the social scientist to determine alone what social policy and plan should be?—who the engineer?—the businessman?—who indeed? None is competent. The job is too big, the ramifications of interest too extensive. But even if one were competent, it would contravene the principle of democracy to have proposed policy arrived at that way. Without a superprofession, and presumably without a dictator, to do our thinking for us, and yet with problems of social policy and plan so complex that expert professional thinking must be given to them, we are, it seems to me, inevitably committed to the more clumsy but democratic scheme of conference or council for reaching intelligent proposals that the people, or legislative groups, might have confidence in. Thus such councils would provide technical expertness, balance of interests, and the effective joining of boundary connections between related fields of social activity. All of these are essential and they cannot be achieved through the policy of professional isolation. The engineer cannot delegate his responsibility to the social scientist.

HOW TO INTEREST THE ENGINEER

But it is idle to talk about social responsibilities which the engineer might assume unless there be some prospect of getting him interested. This is the crux of the matter. I do not have the answer, but I do have a theory. I am clear, in the first place, that there is very little prospect of getting him actively interested by talk. Discussion and exhortation seem ineffectual

in exciting in mature man a new interest—one that will bring action along a line fundamentally different from that of the past. Why this is so, is a matter for the biologist and psychologist; the explanation is not important here, but the fact itself is. Hence I see only little hope in discussion; most mature men are going to continue doing what they have done.

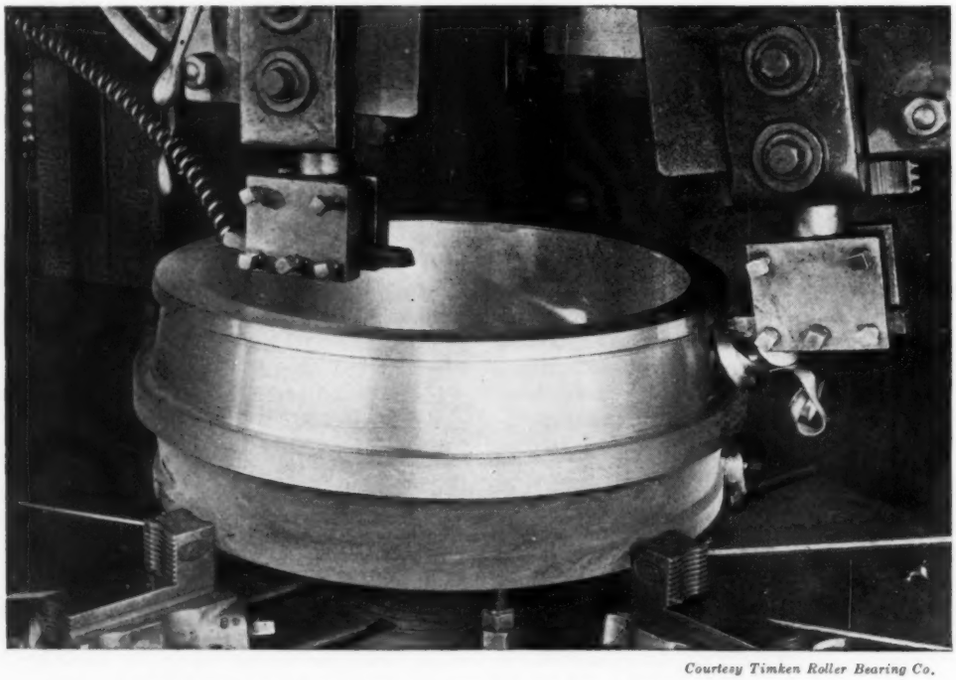
My theory is that active interest will follow competence. Given understanding and intellectual competence in the matter, interest will follow. If my observations are trustworthy, graduates follow essentially the interests they have cultivated in college; if not those within the immediate boundaries of the profession itself, then at least those of both subject matter and method which in college demanded a significant part of their attention. For illustration, in law such matters as social relationships and organization, business, finance, and discipline in careful statement are matters associated directly with the study of law itself. Graduates of law pursue legal practice, but they also gravitate to general management, politics, and banking. In medicine, on the other hand, there is little that is associated with the study of this field that is, at the same time, related so directly to fields outside the profession itself. And graduates of medicine, forming perhaps the most closely knit of the professions, stick close to medicine. And in engineering, again we have diversity. Planning based on clear-headed, objective study and calculation, and the execution of plans, all in connection with material things—these have characterized the dominant interests of engineering students. And the graduates engage not only in technical pursuits, but also in industrial management and business. The question may be legitimately raised whether particular interests are pursued in college and afterward because they are inherent, or whether pursuit in college creates the interest. But the question has little point. The inference we have drawn is that whether the interest exists beforehand or is created, it is nevertheless cultivated in college and this cultivation profoundly influences the direction of later activity.

Here at least is a theory as to how the engineer's interest might be won. It means turning to youth; it means turning to education. If it is essential to the maintenance of a democratic society and to progress in solving baffling social problems to have the talents and the active citizenship of engineers focused upon those problems, habits must be formed in college, interests stimulated, and competences developed which will enable the engineer to cooperate naturally and effectively with educated citizens from other fields who are working toward the same ends.

This theory places responsibility for the initial step in the process squarely upon the shoulders of engineering educators, and this is a heavy and pointed responsibility. The initial step is difficult to take for reasons I have already stated, but unless we are to be in the position of shirking responsibility and of drifting in the face of danger under a policy of technical self-sufficiency, we must act. We must provide in the curriculum enough time and sufficient guidance of the right kind so that our engineering students will have reasonable opportunity to prepare themselves for the responsibilities they will meet in the day they reach professional maturity. If our national situation is difficult to understand and deal with, theirs will be more so; and we must help them get ready.

I need not repeat here the difficulties involved in the fundamental revision of the curriculum. Inadequate time, rigidity of view, vested interest, unwarranted insistence upon specialized skills and knowledge—all of these loom ominously at the first move toward change. I know what they are. But I am clear that we can immensely improve engineering education toward the ends of social understanding and at the same time toward the ends of engineering science and method, and still keep the process within the present framework of undergraduate and graduate study.

I have just said that the responsibility upon engineering educators is heavy and pointed. Other professions may permit the creeping ossification of view to blind them in their mature years to the necessity of change and readjustment, but if this country is to emerge from chaos and endure as a democracy, as a land of free men, then each new professional generation must not be nurtured in the same atmosphere and professional lore as their fathers and grandfathers but in the light and knowledge and purpose of their own day. And if this is to be so, then the teaching profession must make it so. The responsibility cannot be evaded.



Courtesy Timken Roller Bearing Co.

FINISH TURNING A HEAVY DUTY DOUBLE CONE FOR A ROLL-NECK BEARING

BRAKING HIGH-SPEED TRAINS *as an* ENGINEERING PROBLEM

Part II—Departures From Conventional Braking Practice

By JOSEPH C. McCUNE

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(Continued from the August issue)

MODERN ultra-high-speed operation may be said to have commenced with the *Flying Hamburger* some years ago. However, an important distinction should be noted between the development of high-speed operation in Europe and that taking place in America. In the European countries, the development mainly centered in self-propelled cars whereas, in America, train operation, involving a power unit or locomotive and a considerable number of cars, was dominant. In Germany and France, as well as in Italy, these self-propelled cars were relatively light and it was important that all types of apparatus be of minimum weight. Accordingly, automotive rather than railroad practice was followed with respect to brakes. There were two important advantages gained by this procedure; first, the braking pressure was materially reduced because of the high coefficient of friction f possessed by composition block material; second, f for such material was much more nearly constant than f for cast iron. The braking apparatus could, therefore, be made compact and was, relatively, of very low weight. The disadvantage was that the composition brake block, an organic material, could not withstand such high temperatures as cast iron and, for this reason, the horsepower dissipated had to be kept low or artificial cooling had to be employed.

The early automotive-type drums and shoes were soon found inadequate for the loads involved. The next step was to use a large drum, mounted on the axle itself, and adapted to taking the larger braking pressures required to produce the desired retarding force. Such an installation is shown in Fig. 7. It will be observed that the drum is large and relatively heavy. The composition brake blocks can be seen clearly. It is understood that installations of this kind were not considered successful because of the high maintenance costs involved. The braking elements wore and, because of inaccessibility, renewal of parts was expensive. It can be seen from Fig. 7 that the drum was split for convenient installation. It is reported that large centrifugal forces caused the connecting bolts to loosen and made their maintenance a problem.

The Germans passed from drum brakes to disk brakes, with which, it is said, they obtained improved service. One of the early disk-brake designs is illustrated in Fig. 8. This design was superseded by Fig. 9, which, it is believed, represents their latest and most successful design. This design differs from its predecessor in that one pair of brake blocks, instead of two, is employed. Presumably, this change was made to assist in cooling the disks.

The action of these brakes can be better understood by referring to the sectional view shown in Fig. 10. A disk is attached to each side of the wheel. The disks are "pinched" (also shown in Fig. 9) by a single pair of brake blocks through the medium of "ice tongs," operated by an air cylinder. The artificial cooling arrangement is shown in Figs. 8, 9, and 10; Figs. 8 and 9 disclosing the air-inlet passages, and Fig. 10, the fan blades. The purpose of the arrangement is, of course, to produce a strong outward air blast, in order that the disks may be cooled and the composition blocks protected from excessive heat.

The Germans have made disk-brake designs in great profusion, as will be seen in Figs. 11 and 12, taken from an advertisement by a German brake manufacturer. Many of these German designs, however, are for hand, not power brakes. They appear to prefer disks to drums because, with the latter, the heat generated is fed into flat disks with a large surface exposed to the atmosphere, instead of into an annular heavy body such as a drum. Although drum and disk brakes have been employed in France and Italy, the most active development has centered in Germany. It is of interest to note that a number of cars in France have been equipped with brake shoes or blocks, which consist of both cast-iron and composition material. It is hoped by this means to obtain the advantages inherent in each material.

Notwithstanding this great activity in the design of automotive-type brakes in Germany, according to recently published discussion,[1] it is understood that the tendency now is to return to conventional brakes operating upon wheel treads. The recent three-car Diesel high-speed train of the German State Railways was so equipped.

AMERICAN DEPARTURES FROM CONVENTIONAL BRAKING

From what has been said with respect to conventional brakes, it is clear that there is room for improvement. However, the problem is of sufficient magnitude to preclude any simple, off-hand solution. Much thought has been given to the situation and all known or proposed types of brakes have been evaluated as to their advantages and disadvantages. The art, therefore, might be said to be in a state of flux, so that any definite assertions as to final developments would be premature. For this reason, only the high lights of two very different approaches to improved braking will be mentioned.

The new train of the C.B.&Q., mentioned in Part I, has been equipped with brakes which do not act upon the wheel tread. In principle, the brake applied is quite similar to those shown in Figs. 9 and 10. Two disks, each with two faces and a fan interposed between, are used per axle, each disk being bolted to the wheel. Composition blocks act upon both faces of each disk through the medium of ice tongs, each of which has its own brake cylinder. The ice tongs and brake cylinders are supported by a C frame, which in turn is supported by the journal boxes and a bracket near the truck center. This brake, like the European brake previously discussed, has the advantage that the braking friction does not change with speed to

Presented at a Joint Meeting of the Ontario section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS and the Engineering Institute of Canada at Hamilton, Ont., Can., May 11, 1939.

[1] "Braking of High-Speed Trains," Supplement to *The Railway Gazette*, vol. 69, October 28, 1938, London, pp. 752, 753, 765.

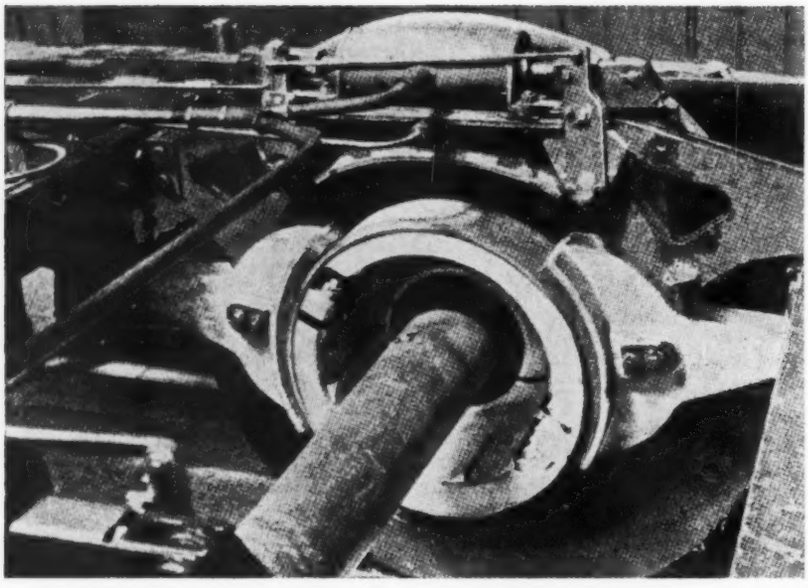

FIG. 7 AN UNSUCCESSFUL AXLE-MOUNTED TYPE OF BRAKE DRUM
(*Verkehrstechnische Woche*, Heft 51, 1936.)

anything like the degree encountered with cast iron. The braking pressure, therefore, does not have to be regulated, as with brakes employing cast iron as the frictional material, to prevent the development of excessive and undesired retarding forces at low speeds. Experience with this brake in American train service should furnish much valuable information in connection with braking problems.

The other development to be mentioned is a complete departure from conventional methods and so far as known, differs entirely from all other approaches. This development has to do with the Rotobrake, the principles of which were tested on a single car in the late fall of 1937 and which since then has been undergoing intensive laboratory development. The name, "Rotobrake" is derived from the fact that the complete assembly takes the form of a rotor, which would rotate if not restrained.

This brake is intended for installation between the truck frame and the wheel. It consists of three principal parts: (1) Rotating elements made of steel and called rotors; (2) stationary elements made of cast iron and called stators; and (3) a ring-type brake cylinder. The rotors and stators resemble large flat rings in that they are flat disks with centers omitted. The rotors are slidably mounted on pins or rods, fastened to the wheel, so that the rotors turn with the wheel and transmit braking torque thereto. The stators are likewise slidably mounted on rods or pins carried by the journal-box structure and are interleaved with the rotors. The ring brake cylinder is also mounted on the journal-box structure and has an annular recess, in which moves a piston, resembling a large, flat, thick ring. When compressed air moves the piston outwardly, the pile of rotors and stators is compressed, so that friction is produced between the rotating and stationary parts. When the compressed air is released springs return rotors and stators against stops, so that positive release clearances are maintained. The dimensions of the brake are such that it can be mounted in the space ordinarily available between truck frame and wheel.

Cast iron and steel were selected as the frictional elements of this brake for two principal reasons: First, these elements will satisfactorily withstand very intense heat. In the laboratory, this brake has dissipated, instantaneously, more than 1000 hp per wheel or more than 2000 hp per axle without thermal distress. Second, f for this brake decreases with increasing speed and pressure as does f with conventional brakes. Brakes of this type will, therefore, harmonize with conventional brakes when both types are operated on the same train.

It has been mentioned that f for cast iron has low values and that it is, therefore, necessary to use high braking pressures with conventional brakes. This handicap of cast iron is overcome in the Rotobrake by using a frictional pile so that the braking pressure is used more than once. This permits the force of the compressed air to be directly applied to the braking surfaces and avoids the use of any levers whatever. Brake rigging is thus done away with and the problems associated with it are eliminated.

The flaming of cast-iron surfaces, previously discussed, is prevented in the Rotobrake by the use of abnormally low unit braking pressures, so that the heat dissipated per square inch of braking surface is well below the flaming value. Reducing the amount of energy dissipated per unit area of the braking surfaces results, in the laboratory, in a phenomenally low wear rate, which is essential in a brake of this type, the frictional parts of which cannot be renewed as readily as conventional brake shoes. Low unit pressures and a plurality of braking surfaces also bring about a remarkable consistency of performance.

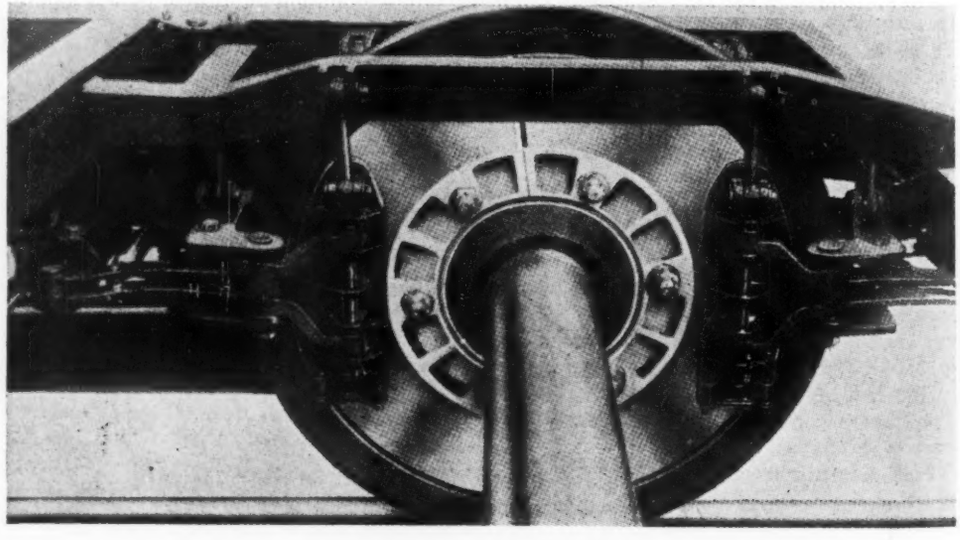

FIG. 8 EARLY TYPE OF DISK-BRAKE DESIGN DEVELOPED IN GERMANY
(*Verkehrstechnische Woche*, Heft 51, 1936.)

It has repeatedly been emphasized that consistency of performance is most important in the modern powerful brake, which frequently operates near the wheel-slipping point.

COMPRESSED-AIR EQUIPMENT

It was pointed out early in this discussion that, almost entirely, the brake art involves transient phenomena. This statement applies with particular force to the compressed-air equipment, which, incidentally, represents still further specialization in a specialized field. This equipment has to do, of course, with the development, storage, and use of compressed air for braking purposes. In the use of this compressed air, flow is evidently involved but a kind of flow not ordinarily encountered.

Various works on thermodynamics give formulas for the flow of air in long pipes or through orifices. In fact, many papers have been presented which deal with the flow of compressed air through orifices. But all these formulas and investigations are concerned with steady or laminar flow and it is generally emphasized that the findings apply only to such flow. With compressed-air equipment, on the other hand, the flow of greatest interest is highly turbulent. It is, therefore, not covered by ordinary formulas and indeed requires experimental investigation in every case. Since the velocity of flow frequently approaches the acoustic velocity, reflected waves and surges are encountered, just as studied by Prandtl in connection with aerodynamic theory. In fact, the acoustic velocity sets a limit to what can be done with compressed-air equipment, in precisely the same manner that it sets an upper limit to the speed of the modern airplane. It will be apparent from the foregoing that the development of compressed-air equipment involves a great deal of experimental research.

It is clear that departures from conventional practice with the brake proper have called for departures from conventional practice with respect to the compressed-air equipment. One of these departures is the use of electropneumatic equipment on high-speed trains operating in segregated service instead of the usual pneumatic equipment. Since the acoustic velocity sets a functional limit for straight compressed-air equipment, when it is desired to apply all brakes throughout a train simultaneously, it is necessary to add electrical control to accomplish this.

The advantages of a simultaneous application of all brakes throughout the train may not be fully appreciated by engineers unfamiliar with the brake art. It will be recalled that emphasis was given, earlier in the discussion, to the fact that a brake application sets up a retarding force at each wheel of the train. Since the train is made up of an aggregation of cars, more or less loosely connected together, it is evident that, if there is a time lag in the serial application of the brakes on the several cars, different retardations will be produced on the cars with the result that cars may collide and produce undesirable shock. It is also apparent, that for a given time lag, the internal collisions or shocks become greater as the brakes are made more powerful. Consequently, electropneumatic control is one of the important aids in the satisfactory handling of powerful brakes.

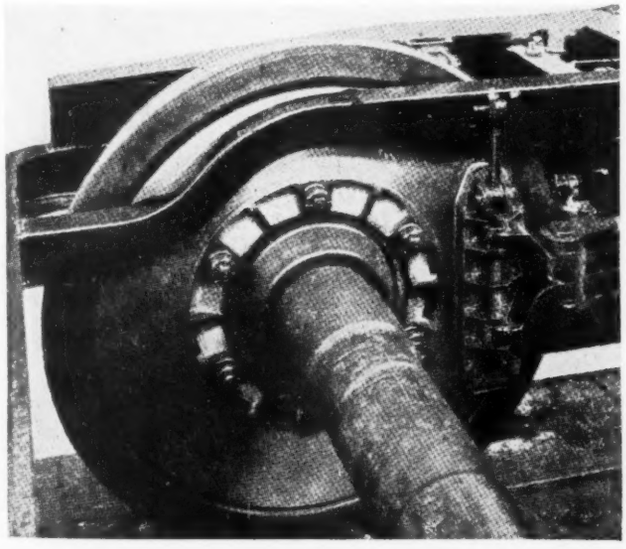

FIG. 9 LATEST AND MOST SUCCESSFUL TYPE OF GERMAN DISK BRAKE, HAVING ONE PAIR OF BRAKE BLOCKS
(Supplement to *The Railway Gazette*, May 27, 1938.)

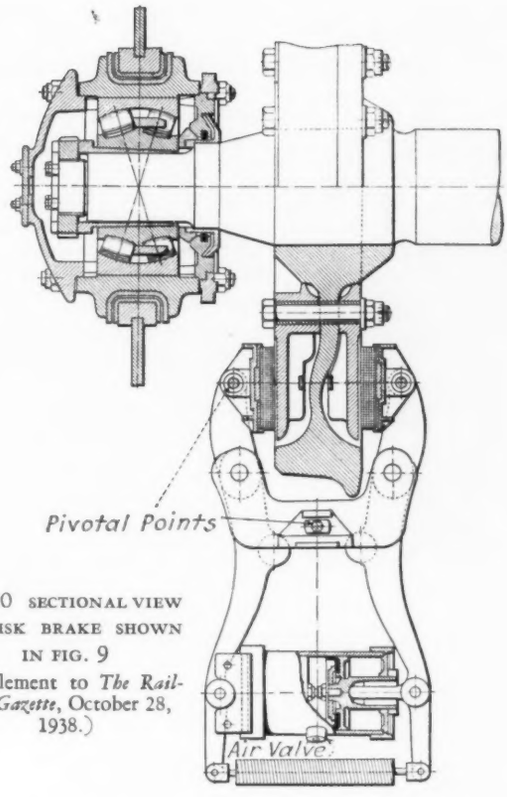

FIG. 10 SECTIONAL VIEW OF DISK BRAKE SHOWN IN FIG. 9
(Supplement to *The Railway Gazette*, October 28, 1938.)

A second departure from conventional practice is in connection with control of the cylinder pressure obtained in an emergency application. For many years, the emergency cylinder pressure had a fixed value and was held constant throughout the stop. But, for reasons already explained, with cast-iron brake shoes, it was necessary to produce a higher pressure at the higher speeds, under the new operating conditions. If this pressure were retained throughout the stop, wheel sliding would be encountered at the lower speeds. The emergency pressure is, therefore, no longer fixed but is, on the contrary, variable. Two methods have been used to control this pressure; one based on inertia, and one based on speed.

The inertia method is based upon the principle that the retardation itself is a direct measure of the adhesion called for. Thus, retardation of 2.2 mphps indicates an adhesion demand of 10 per cent. The retardation is measured by a mass free to move in the direction of train movement, except as restrained by a calibrated spring. The degree to which the spring is compressed is a direct measure of the retardation. Inertia devices have two forms; first, the retardation-controller type, in which the free mass is in the form of a pendulum; and second, the Decelakron type, in which the mass is a rectangular block, free to move on nonfriction bearings. When these devices measure

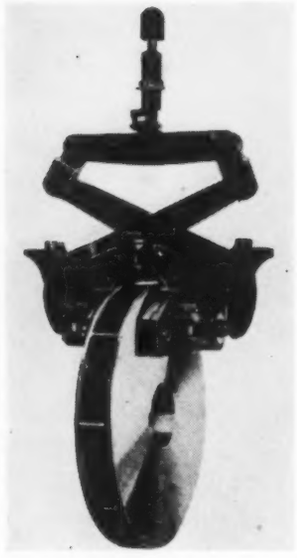

FIG. 11 A TYPE OF BRAKE ADVERTISED IN THE GERMAN PRESS

nor, if a stop is made from the highest speed, the maximum pressure is secured which is thereafter reduced as the speed decreases. It will be noted that the speed governor is not influenced by internal train-slack shocks, which, under certain conditions, may be undesirably recognized by inertia mechanisms.

Although the principal changes in compressed-air equipment have been referred to, it should be understood that many other differences are involved. In fact, the compressed-air equipment on segregated high-speed trains is entirely different in structure and, in many respects, in functioning, from that long used on conventional passenger trains.

CONCLUSIONS

It has been the author's endeavor to point out various aspects of the high-speed braking problem which might be of interest to engineers. In closing, it seems advisable to refer to a principle followed in the brake art which should be of general interest, namely, that improvements should always be of such a character that they will harmonize completely with existing apparatus.

a predetermined retardation, the pressure braking is reduced, independent of any action by the engineman. It is understood that retardation controllers have lately been introduced in Germany.

The speed method involves the use of a speed governor whereby the cylinder pressure obtainable is proportioned to the actual speed of the train. In the United States, the cylinder pressure obtained is in four steps or speed ranges; in France and Germany, it is continuously changed with the speed. With a speed gover-

The importance of this principle was early recognized, as stated by George Westinghouse in his presidential address before The American Society of Mechanical Engineers. But, like many familiar things, the principle is taken for granted and the benefits accruing from it are not clearly recognized. It is the practical application of this principle which permits a railroad car to move from Canada to Mexico, or anywhere in the United States, without restriction. The great importance of such movements, both to commerce and to national defense, needs only to be stated to be recognized. If any proof were required, it could be supplied by pointing out that the contrary condition exists in Europe. Its handicaps were so evident during the World War that the Treaty of Versailles contained a clause requiring standardization of brakes in all European countries so that cars might be freely interchanged. That such standardization already exists in Canada, the United States, and Mexico, should be a source of satisfaction, not only to those directly concerned with the brake art, but to all citizens.

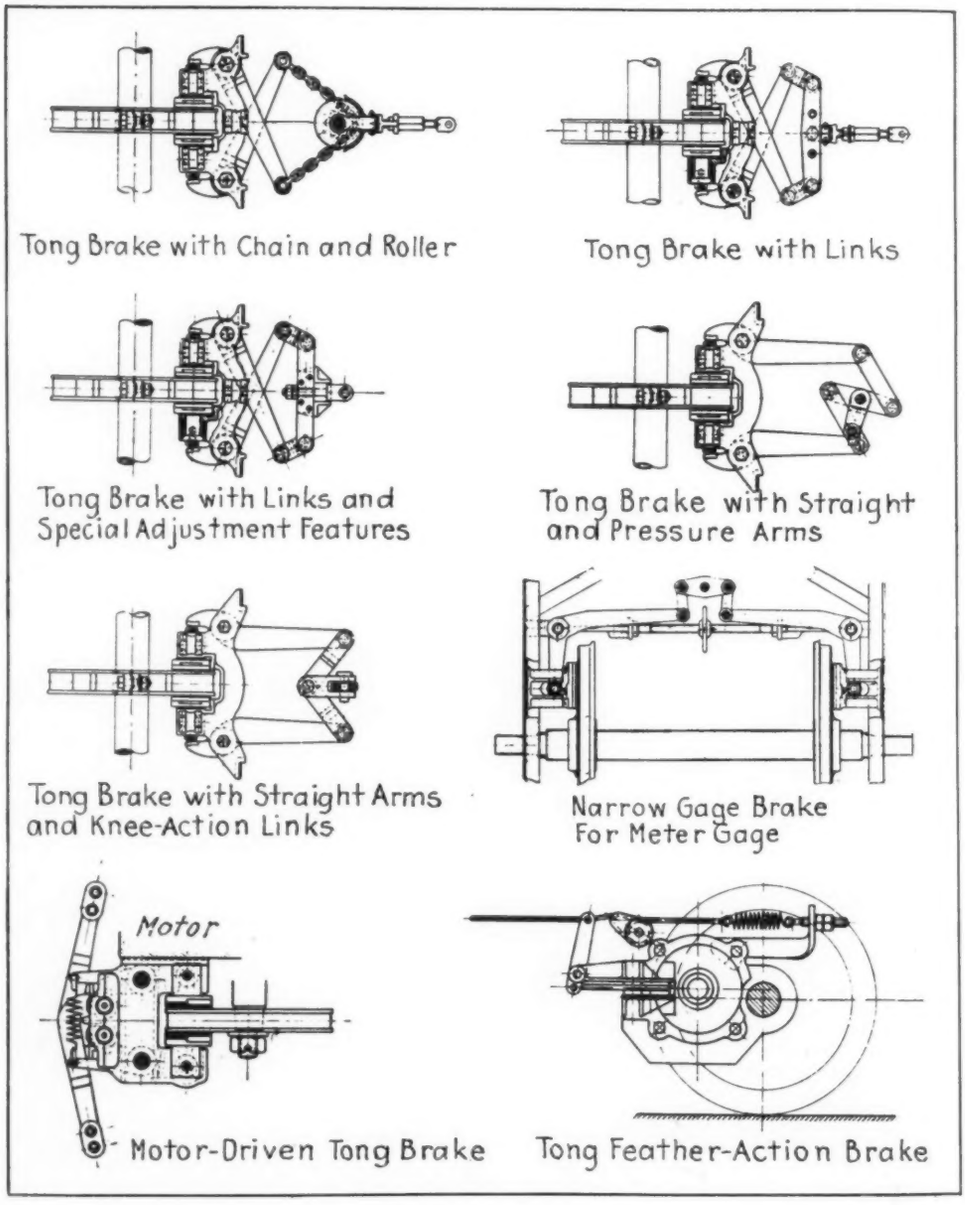
Tong Brake with Chain and Roller
Tong Brake with Links
Tong Brake with Links and Special Adjustment Features
Tong Brake with Straight and Pressure Arms
Tong Brake with Straight Arms and Knee-Action Links
Narrow Gage Brake For Meter Gage
Motor
Motor-Driven Tong Brake
Tong Feather-Action Brake

FIG. 12 A VARIETY OF DISK-BRAKE DESIGNS PRODUCED BY ONE GERMAN MANUFACTURER

(Bezeichnung der BSI—Scheibenbremsen.)

The DEVELOPMENT *of* NEW PRODUCTS

By A. R. STEVENSON, JR.

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

NEITHER INDIVIDUALS nor corporations can stand still; they either must go forward or backward. A corporation can go forward in two ways:

1 The existing lines of business can be enlarged by improving the quality, reducing the cost, selling a larger percentage of the market, and, in many cases, increasing the breadth of the market.

2 New markets can be entered by the development of new products and new departments to handle them.

This paper deals primarily with the development of products which bring a company into new lines of business. However, it is of equal or greater importance to develop radically new products as additions to the lines of business in which a company is already engaged. The same general fundamental principles apply in both cases.

ORIGINATION OF A GOOD IDEA

It is often asked how good ideas for new products are originated and this is very difficult to answer. Perhaps suggestions for new products may be roughly divided into four classes.

1 One way is to find out what the public wants and then supply the demand. This is certainly one successful way of making minor improvements in existing lines, but probably, it is seldom if ever that the general public thinks of anything radically new.

One of the more recent home appliances is the Disposal which grinds waste food and flushes it into the sewer, thus eliminating the garbage problem. It is not likely that this idea could have originated in the mind of the housewife. It is necessary for the engineer to get such ideas and sell them to the public.

2 Suggestions for new products sometimes result from an individual's saying to himself: "Since I am a member of the general public, what would I like to have? Is there anything which I could make use of with comfort and convenience, which is obviously lacking?" Such ideas can be checked in conversation with one's friends.

Using the same illustration, the idea for the Disposal probably came from the inventor's desire for a method to eliminate garbage in his own home.

3 It can be said that really outstanding new products, however, cannot be invented to order, but come spontaneously from imaginative minds. The real problem is to recognize and properly evaluate the worth of a suggestion. We are probably familiar in a vague way with many ideas which would lead to worth-while new products some day, if only we had sufficient imagination to visualize the future. The same idea may be mentioned again and again over thousands of years without flowering into anything of value, until the evolution of the world reaches a point where it becomes possible. The airplane was suggested in the ancient Greek myths of Daedalus and Icarus and in the Arabian legend of the flying carpet. Leonardo da Vinci made quite a scientific study in the Middle Ages and constructed a sample airplane, but the world was not ready for it either technically or psychologically. Without the modern internal-combustion engine, it was impossible and, even today, more than thirty years after the Wright brothers' first flight, the general public has not been completely sold on the possibilities of aviation.

A search of ancient literature by an individual with second sight might reveal suggestions for other new products which today look as ridiculous as aviation did forty years ago, which tomorrow might be just as practical.

Coming down to more modern times, Jules Verne wrote a whole series of imaginative books a generation ago, such as "Around the World in Eighty Days" and "Twenty Thousand Leagues Under the Sea," which described things impossible at the time, but which have come to pass in our day. Another of his books suggests the possibility of manufacturing diamonds. Carborundum and carboloy are already here; and some small diamonds have already been made; and none of us would be greatly surprised if some one produced really big ones like the ones Jules Verne described.

Dr. Whitney told me that Sir Francis Bacon[1] a few hundred years ago listed twenty-two needed inventions, twenty one of which have already been produced. Lord Kelvin in 1852 suggested heating houses by refrigerating machines, something which has only begun to be done practically within the last few years.

The Renaissance in the fifteenth century in Europe was partly due to ideas rediscovered from the old Greek literature. Perhaps new products suggestions could be obtained by a careful, intelligent study of the writings of imaginative men, both ancient and modern.

In an article[2] of quite recent date S. C. Gilfillan states:

"Taking 19 inventions voted most useful, introduced in 1888–1913, the average intervals were: Between when the invention was first merely thought of, and the first working model or patent, 176 years; thence to the first practical use, 24 years; to commercial success 14 years; to important use 12 years or, say, 50 years from the first serious work on the invention."

In modern times, inventors are encouraged to record their ideas for new products with the Patent Office. Many of these suggestions are impractical at the time the patent is issued. Perhaps a careful review of expired patents would give germs for new ideas which, in the light of modern improvements, could be made practical, just as the airplane has been made practical by the development of the internal-combustion engine. A vague general search is not recommended but a limited search in a particular field is sometimes helpful.

Dr. Whitney suggests that perhaps engineers should be warned against too great effort on long-wanted or prescribed needs. Long-felt wants like perpetual motion, the philoso-

Presented at the Annual Meeting of the Society for the Promotion of Engineering Education, State College, Pa., June 19, 1939.

[1] "New Atlantis."

[2] "Prediction of Inventions," by S. C. Gilfillan, from the report, "Technological Trends and National Policy," of the National Resources Committee, June, 1937.

pher's stone, the fountain of youth, and water substitutes for fuel oil are not promising fields for development. He feels it is better to wait for new accidental discoveries and then try to apply them to the solution of long-felt wants.

In Darwin's theory of evolution, the development of new species is always accidental. An article[3] by Rose Wilder Lane has pointed out that many of the most valuable governmental accomplishments in the United States have been made accidentally. An effort to do one thing, in many cases, has resulted in something entirely different but much better than what was intended.

This article points out that the rapid progress in the United States which appears accidental is really the result of individual liberty. The sum total of accomplishments by individuals in the United States all working on their own initiative is far greater than the results obtained in Europe, where the individual has been too much hampered by centralized authority. Similarly, some of the germs for new ideas and the background for basic developments seem to originate and be present in industrial organizations almost by accident. But this is really the result of the broad-minded policy of encouraging individual initiative and allowing engineers the latitude to push basic developments in some cases years ahead of the commercial demand.

Lewis Mumford[4] points out that luxury toys usually preceded useful inventions. Hero's steam engine was a toy. The helicopter was first invented as a toy in 1796. The gyroscope was a toy. The toy airplane came before the real thing. The most powerful engines of the seventeenth century, the water wheels at Marly, were constructed to pump water into the great fountains at Versailles. The promenade aérienne, our present scenic railway, preceded the railroad and motor car.

In many cases the suggestion or toy remains impracticable because the means are lacking or are unreasonably expensive until some real inventor makes an additional discovery, or the progress of industry has reduced the component parts to a reasonable cost. As noted previously, the internal-combustion engine was needed in order to make the airplane practical.

4 Probably the best way of arriving at new products suggestions is by a reanalysis of old problems under the light of modern developments. For example, products which were impracticable because of the lack of a good magnet are now possible with Alnico. As the cost of capacitors decreased, certain circuits became economically feasible for the first time. The capacitor motor which had been a failure forty years before, when first developed by Dr. Steinmetz, has become universally popular now that small, inexpensive, reliable capacitors are available.

It seems that the real problem is not a lack of new ideas but a lack of the proper combination of imaginative ability and practical common sense to decide whether an idea is good, and whether the world will be ripe for it in the near future, and to find economical means for its accomplishment.

There is no use in pushing an idea too far ahead of its time. Many are suggested years and even hundreds of years before the world is ready for them. Civilization must progress to a certain point before they are successful. There would have been no real purpose in developing an electric refrigerator years before there were wired homes. Furthermore, even with all the material obstacles overcome, there is quite a psychological delay while the public is being awakened to a desire for the new device.

Perhaps the development of a new idea can be compared to the development of an egg. If a certain amount of heat is applied slowly at a reasonable temperature over a period of weeks, the result is a chicken, but if one tries to hurry the process by supplying the same amount of heat much more rapidly at an advanced temperature for ten minutes, the result is a hard-boiled egg. On the other hand, if one does not keep the egg warm enough and the development goes too slowly: it gets rotten. To put the same idea in a slightly different form, you can not hatch the egg more quickly by getting two hens to sit on it.

There is a certain optimum rate at which new things may be developed. It is inefficient to go either slower or faster than this optimum rate.

There is a feeling that markets develop more rapidly today than previously. Probably the entire tempo of civilization has been speeded up but, according to Burlingame:[5]

"In the year 1860, about 111,000 sewing machines were made in the United States. This was a little less than ten years after the invention came on the open market."

It is hard to match this in modern exploitation. Burlingame shows, however, how opportune the invention of the sewing machine was.

PRELIMINARY PROCEDURE

With all the good ideas floating around and with engineers always on the search for them, the procedure for their development is usually somewhat as follows:

An individual, while carrying on in some field of endeavor runs across an idea. After thinking it over and discussing it with his friends, this individual finally comes to the conclusion that the idea is worth promoting. He then, on his own responsibility, puts a certain amount of preliminary study on the subject, collecting information, thinking out various ways of overcoming obvious difficulties, sketching a rough design, making an educated guess as to the probable cost, price, and market, and perhaps considering superficially whether the idea is too far in advance of the market and what the present competition is.

Sometime during these deliberations, he would probably discuss the idea with the head of his department. If the idea appeared good to the department head and came within the scope of that department, a small appropriation might possibly be requested. Whenever the desired appropriation is more than a small amount, the interested commercial department should be consulted and asked to share the responsibility.

If it does not come within the scope of that department, perhaps it might be referred to another department, which might be interested. Of course, records should very promptly be made for patent applications on all good ideas.

One of the first steps before undertaking a development which would lead into a new field, either within the scope of an existing department or which might require the organization of a new department, is to survey the market. In the case of a household electrical appliance, for example, by comparing it with existing devices, using data on the number of incomes over a certain size, the number of new houses costing a certain amount, the number of wired homes which might be potential customers, the number of existing devices which have been sold in the same price class to the same type of customer, a pretty good guess can be made as to how many people can afford to buy it. During this survey, a check will be made to see what the existing competition is and to study the indirect effects on the company of entering a new market, such as the possibility of antagonizing customers in other fields.

[3] "Credo," by Rose Wilder Lane in the *Saturday Evening Post*, condensed in the May, 1936, *Reader's Digest*, says: "The characteristic of American History is that everything appears to happen by accident."

[4] "Technics of Civilization," by Lewis Mumford, Harcourt Brace & Company, New York, N. Y., 1934, p. 101.

[5] "March of the Iron Men," by Roger Burlingame, Charles Scribner's Sons, New York, N. Y., 1938, p. 374.

Considerable imagination, however, is required in applying such statistics in the attempt to predict a market for some radically new things. Statistics on horses would probably not have indicated the huge market for automobiles.

In order to predict the complete market for a new material like Alnico, it would be necessary to prophesy many uses not thought of yet.

The inventor must have unfailing enthusiasm, tremendous energy and ability to persuade in order to get assistance and help in going through the preliminary stages of revising drawings, making market research and preventing his idea from being put into the classification of "not being worth working on yet."

IMPORTANCE OF GETTING STARTED

There are engineering, patent, and commercial reasons for getting started at the proper time.

ENGINEERING AND PATENT REASONS FOR PRELIMINARY EFFORT

If an idea has promise for the future, even though the market research shows an insufficient demand for the commercial development of the article at the time, the engineering and patent situations should be thoroughly protected by carrying out such fundamental or basic development as is necessary. This very often must be done at least five years before the time is ripe for exploitation. Basic or fundamental development usually does not involve large expenditures. It is the later development of the commercial article, particularly the final drawings, tooling, and initial production, that involves great expenditures. A decision with regard to these larger expenditures can be deferred until the commercial market is more closely in sight but, if the fundamental engineering is not done ahead of time, a company might find itself blocked by adversely held patents later on, when the commercial situation would look more favorable.

In this fundamental or basic development, one should not be too discouraged by the high cost of details because, if there is later sufficient demand for the product to justify the effort, the costs of the component items can very often be reduced.

As previously mentioned, capacitors, which in 1923 were prohibitively expensive, have been reduced in cost so that the capacitor motor which was then out of the question is now the most promising item in the fractional-horsepower line.

A great deal of money can be saved in the fundamental or basic development by proceeding in a cautious and orderly manner. In the first place, a great many difficulties can be overcome on paper. Again and again appropriations to build an expensive sample have been refused, but the engineer has been encouraged to do paper work. In most of these cases, six months or a year later, the inventor has a design so much better that he is grateful for having been prevented from building the earlier model.

It is at this point that studies in machine design and theoretical mechanics are particularly helpful in producing a paper design which will not exhibit fundamental weaknesses when a sample is constructed.

In refrigerator design, theoretical mechanics is required for the balancing and spring mounting and the fatigue of valves. Heat transfer and fluid flow must be studied in connection with the evaporators, condensers, and lubricating systems.

At this point, every one who can contribute should be consulted. There are questions of metallurgy and chemistry, and methods of fabrication, which should be considered.

Many complete designs consist of known and unknown features. Money can often be saved by experimenting individually with the unknown features rather than attempting to incorporate them into a complete sample of the machine.

When the time arrives to build a complete sample, it will usually save money not to try to build more than one or two at the beginning, because otherwise the mistakes will be uselessly multiplied.

COMMERCIAL REASONS FOR GETTING STARTED

When a product is first put on the market, it is usually necessary to do business at a loss while the engineering and factory departments are increasing and smoothing out production to reduce costs. It is also difficult to make money because of the large sales-promotion and advertising campaigns necessary to sell the public a new product.

The next stage, when the design has been stabilized, production difficulties overcome, and public acceptance has been reached, should be quite profitable.

In many instances, a final stage has later been reached when hundreds of irresponsible competitors spring up, doing business sometimes even at a loss and often not including sufficient margins in the profits to pay for the continual improvement in design and production which is necessary for continued success.[6] It is, therefore, evident that there is an opportune time when a new product should be exploited. The development should be planned to meet the market at that time. It is very expensive to push it before its time, but it is necessary to get into production and become well established in the market before the competitive stage arrives. If a sufficiently low-cost quantity production can be reached before too many other competitors begin to cut the price, it is sometimes possible to continue almost indefinitely exploiting a particular product at a profit.

Do not forget the story about the egg!

REANALYSIS FOR PRELIMINARY DECISION

A time arrives in the development of a new product when a real decision must be made as to whether to proceed actively. After what looks like a more or less final design has been made and a few samples tried out, the drawings should be given to the factory to plan and cost estimates prepared in various quantities. During this planning, the factory will probably have suggestions as to how this design could be improved to make it easier to manufacture. When the cost estimates are available, they should be compared with the market research reports to see whether the design and cost are at all within reason.

At this point it is well again to consider the project broadly to see whether there is any hope of getting low enough costs to obtain a sufficient market to justify the development. Perhaps the design will have to be abandoned and completely restarted along radically different lines.

The General Electric Disposal or kitchen-waste unit is a good illustration. The real pioneer on the Disposal had the idea, the vision, the courage, and the persistence to build several samples which worked beautifully. They would grind glass bottles and tin cans as well as anything else. The design was too costly and it was not necessary or advisable to grind this heavy rubbish which would have sunk in the sewer pipes instead of floating to the sewage plant.

The head of the Schenectady works laboratory of the General Electric Company saw that the cost would be too high and waved a red flag. He put another engineer on the job, who developed a fundamentally different type of grinder which would cost less to manufacture. A few samples were made and tried out in the homes of company engineers.

A sanitary engineer was employed to study the effect of in-

[6] When prices are reduced to the point where no one can afford to make improvements stagnation may result until someone has the courage to take the next step required to leave the imitators behind.

jecting ground food wastes into the sewers. He reported that these would float successfully through the sewers and digest properly in the biological tanks at the disposal plant.

PROJECT TRANSFERRED TO A PRODUCTION DESIGN DEPARTMENT

It is at this point that the project should be transferred from the laboratory to a regular operating department. In this case, although the Schenectady works laboratory made the first few samples, the job was transferred to Fort Wayne when two dozen samples were desired.

The design and fabricating organization must assume the responsibility for the design and manufacture of a device which will meet market conditions as to suitability and cost. Care must be exercised, at this point, not to allow others in a company to gain the impression that the development is completed when it leaves the laboratory. It is expected that, whenever the laboratory turns a development over to the factory, the factory will first make samples identical to those the laboratory has made and then determine the suitability of these samples, before proceeding with the final manufacturing process. The kitchen-waste unit is a development where these transfers were made in the proper manner.

The department head selected an engineer to go over all the drawings. This engineer made a couple of dozen samples, introducing certain changes which field tests on earlier samples indicated to be advisable. The samples were placed in the homes of distinguished sanitary engineers, selected by the company's sanitary engineer, for field tests.

At this stage of a development, no undue pressure or haste to place an article into production should be permitted before that article is fully developed to the point of meeting the commercial requirements.

FINAL DECISION

The manner of making a final decision may best be illustrated by continuing with the procedure followed on the kitchen-waste unit. After about a year of trial of the new samples in homes, the whole matter was resurveyed carefully and a decision was made to go into the business. Design and manufacturing organizations were set up, a commercial man appointed, and the project was launched. A few thousands were then made and sold.

In making a final decision, a great many things have to be taken into account. With the kitchen-waste unit, there was the question of how difficult it would be to persuade the sanitary engineers and plumbing inspectors of the various cities to permit their installation. Considerable progress has been made along this line and recently the commercial department has reported that its sales efforts are not being retarded for lack of approval.

Although these early machines operated successfully, the engineer was not satisfied either with performance or cost. He redesigned the device again, making it much better and still less expensive. This new design has been successfully placed in production during the last year. This illustrates the fact that no design is ever finished. Good engineers can always make improvements. Minor improvements can be made all the time but continually to make radical improvements upsets production. New ideas should be developed on paper and in the model room and accumulated for introduction periodically whenever it is advisable to make another big step forward.

MAINTENANCE OF POSITION

It is not sufficient to make a successful introduction of new products. Continued improvement is necessary to hold a leading position in any line of endeavor. In retrospect, it appears that it is almost easier to break into a new business than it is to maintain one's position. In maintaining a position in any industry, there are three main factors of importance:

1 Design and manufacture must be such that costs can be obtained, justifying prices which are not so high as to tempt others to cut under them.

2 The product should have outstanding features which make it possible to sell against competition.

3 It is always necessary to be preparing new designs against the day when another step forward is required. Ford made a grand success of his Model T but was ultimately forced to change to something better. We cannot afford to change designs every year, but it is essential to be prepared to change designs every five years if necessary.

CONCLUSION

The country needs new projects to take up the slack in the national economy and to give greater employment both to labor and capital. It is natural to look to the colleges to produce the future leaders who will have the originality, courage, and persistence to carry on this expansion program successfully.

In a recent article by Wickenden,[7] there is one paragraph which so completely sums up the necessity for the development of new products that it provides a fitting closure to the thought the author has attempted to convey in this paper. It follows:

"Every engineer knows that permanent gains in wealth and leisure are the by-products of rising efficiency and cannot be created by government subsidy; that the way to cure unemployment is to create more jobs through research, thrift, and enterprise, by development of new products, by creating new industries, and by translating technical advances into reduced prices and wider markets. One quarter of all our employment today is said to be in industries which did not exist before 1880."

Synthetic Wool From Milk

PRODUCTION of a synthetic fiber requires a plentiful supply of a cheap raw material. In the manufacture of synthetic wool, the raw material is casein obtained from skim milk. Commercial casein is generally made in two forms, rennet casein and acid casein, and it is the latter which is used for spinning these fibers. Acid casein may be made either by precipitation from milk by mineral acids, or by separation after allowing the milk to sour. The dried product is made into a solution using dilute caustic alkali. The process of manufacture is similar to that of other synthetic fibers, the solution being extruded through fine holes into a coagulating bath. The chemicals however, are different; formaldehyde and aluminum salts are used in this treatment and the rendering of casein insoluble by these chemicals is a most important part of the process.

Casein fiber has a specific gravity of 1.26 which is very close to that of wool (1.30) as compared with 1.50 for cellulose fibers. Casein is much less inflammable than cellulose staple fibers and cotton, and is distinctly warm to the touch. It is characterized by a considerable crimp which is fairly resistant to processing treatment and has a moisture regain somewhat similar to wool. Although the spinning process now employed will yield fibers of infinite length, the practice has been to cut these fibers into short lengths, corresponding to the staple of natural wool, so that the staple fiber obtained can be worked with the equipment of the wool spinner. Provided the casein fiber is previously humidified, the carding proceeds as easily as with wool, and there is no need for any preliminary scouring or finishing.—Abstracted from article by Claud Diamond and Robert L. Wormell, in *The Dyer & Textile Printer* (Great Britain) for June 16, 1939.

[7] "The Young Engineer Facing Tomorrow," by William E. Wickenden, MECHANICAL ENGINEERING, May, 1939, pp. 347–348.

AIR FLOW *in* PIPES

The Application of Sound Pulses to the Measurement of Velocity

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THE AUTHORS have previously described an absolute method for measuring the velocity of air flow through pipes.[1] The method was based on the measurement of the position of steady-state plane interference nodes and the shift in their position caused by the superposition of the velocity of the fluid on the velocity of propagation of sound waves in the stationary fluid. Difficulty was experienced in the application of this method owing to the interfering effect on the sound nodes of reflections from the ends of the pipe. This disturbance was avoided in the apparatus described by interrupting the sound trains and determining the position of a node during a time interval when the pipe was free from the disturbing reflections. The accuracy of the velocity determinations made gave promise of the possibility of successfully extending the application of the method.

The apparatus now to be described depends upon the propagation of sound pulses rather than upon sinusoidal-wave trains, and the determination of the time of arrival of the pulses at two locations in a pipe through which the fluid is flowing. The effect of pulse reflections is avoided by use of a vacuum-tube circuit which operates once for each pulse sent out. Upon the arrival of the outgoing pulse at one of the two receiving locations the apparatus indicates the arrival and prevents later pulses from registering.

THEORY OF OPERATION

Referring to Fig. 1 sound pulses of steep wave front are produced by the telephone receiver R_3, upon closing the switch S_1. A motor-operated contactor, not shown, was employed to produce the following cycle of events: (1) momentary closure of switch S_1, (2) momentary opening of switch S_2. The purpose of (2) of the cycle is to restore the indicating circuit to its receptive initial state, as will be better understood later.

The pulse originating at receiver R_3 is transmitted through the isolating membrane M_3 to point 1 in the pipe conducting the fluid. From 1 the pulse proceeds in two directions, (*a*) upstream to 2, through membrane M_1 to 3 where it impinges on the diaphragm of receiver R_1; (*b*) downstream to 2′, through M_2 to 3′ and R_2. With the fluid in the pipe at rest the path 1-3 is adjusted by means of a telescoping tube so that the divided sound pulses arrive simultaneously at the two receivers R_1 and R_2. The position of a pointer on the telescoping tube is then noted on a fixed scale, and this reading constitutes the zero indication. To understand how the zero indication is obtained it is necessary to explain the operation of the associated electronic circuit.

The circuit includes two coupled gas-filled tubes of the R.C.A. 885 type. The plates P_1 and P_2 of both tubes are fed from a common battery E_B, through a resistor R. The two coils W_1 and W_2 of a differential milliammeter are connected as shown so that the milliammeter needle N deflects to the left or right according as plate current flows to P_1 or P_2. The grids g_1 and g_2 of the tubes are biased through grid resistors r_1 and r_2 by means of batteries Ec_1 and Ec_2 so that when switch S_2 is closed neither one of the tubes passes plate current. Now suppose that an amplified electrical impulse originating at receiver R_1 arrives at g_1 and raises its potential beyond the critical point for the given plate voltage. Under these circumstances tube T_1 ignites, that is, passes plate current, and in consequence the plate potential on the companion tube T_2 is reduced because of the iR drop in R. This condition would remain unchanged, regardless of the subsequent arrival of impulses at either g_1 or g_2. In other words, if both grids are subjected to a succession of positive impulses, the device indicates the first arrival of an impulse at either g_1 or g_2. The opening of switch S_2 restores the plate circuit to its original nonconducting condition. Consequently, the cycle previously described, namely, the closure of switch S_1 followed by the momentary opening of switch S_2 serves to indicate whether the sound pulse entering the pipe at 1, arrives first at R_1 or R_2. By lengthening or shortening the distance 1-3 by means of the telescoping tube it is possible to cause the impulse arriving at 3′ to appear either earlier or later than the impulse arriving at 3. Thus an intermediate zero scale position can be determined.

On the other hand, if the fluid in the pipe is flowing from left to right, the time required for a sound impulse to travel from 1 to 2 is increased whereas the time of travel from 1 to 2′ is diminished. Consequently the length of path 1-3 must be shortened in order that the sound pulses may arrive at 3 and 3′ simultaneously. The difference between this new length and the original length as indicated by the scale readings is a measure of the fluid velocity. Thus if s is this difference in length, a the length of the equal paths 1-2 and 1-2′, and V the velocity of sound propagation in the fluid at rest, then the velocity of the fluid as will be shown is given by

$$v = (V/s)[(a^2 + s^2)^{1/2} - a] \quad \ldots\ldots\ldots\ldots [1]$$

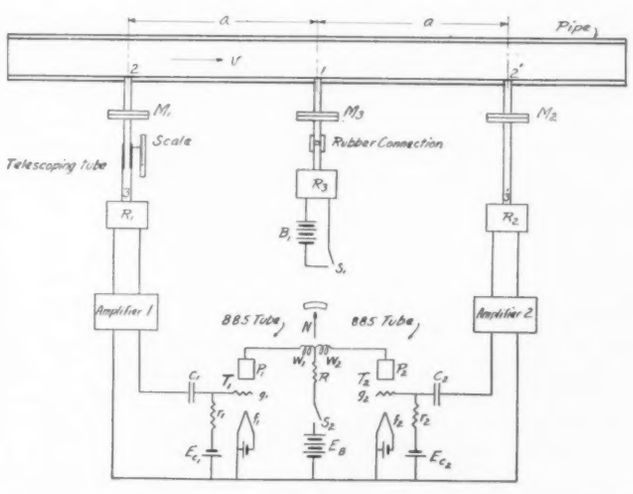

FIG. 1 SCHEMATIC DIAGRAM OF APPARATUS FOR MEASURING VELOCITY OF AIR FLOW BY SOUND PULSES

[1] "An Absolute Method for Measuring the Velocity of Fluids," by H. E. Hartig and H. B. Wilcox, *Physical Review*, vol. 29, no. 3, March, 1927, pp. 485–490.

Contributed by the A.S.M.E. Special Research Committee on Velocity Measurement of Fluid Flow.

THEORY OF VELOCITY MEASUREMENT

If the velocity of the fluid is uniform in the pipe between A and B, Fig. 2, then the velocities of travel of sound pulses from O to A and from O to B are $V - v$ and $V + v$, respectively, where V is the velocity of sound propagation in the pipe with the fluid at rest, and v is the velocity of the fluid. The times required for the pulses to travel from O to A and from O to B are $a/(V - v)$ and $a/(V + v)$, respectively. Then

$$\Delta t = \frac{a}{V - v} - \frac{a}{V + v} = \frac{2av}{V^2 - v^2}$$

But for simultaneous arrival of the sound pulses at receivers R_1 and R_2, Fig. 1, it is necessary that $\Delta t = s/V$ where s is the shift from the zero position on the scale; it is understood that as a special case the velocity of sound propagation in the telescoping tube is the same as in the fluid occupying the pipe. Hence

$$v = (V/s)[(a^2 + s^2)^{1/2} - a] \quad \ldots\ldots\ldots\ldots [1]$$

Now the velocity of the fluid is usually small compared with the velocity of propagation of sound in the fluid, and this fact may be used to derive a simpler formula for v. Thus when v is no larger than 2 per cent of V, Equation [1] may be replaced by

$$v = Vs/2a \quad \ldots\ldots\ldots\ldots\ldots\ldots [2]$$

with an error no larger than 0.04 per cent. For the range of velocities encountered in this investigation the approximate formula given by Equation [2] is more than adequate as to accuracy.

The choice of the length $2a$ between the two receiving stations in the pipe depends upon the minimum velocity of fluid flow it is desired to measure, the accuracy desired, and upon V. For example, if a velocity of 2 fps in air is to be measured with an accuracy of 1 per cent, then from Equation [2]

$$v/V = 2/1130 = s/2a$$

and since it was found by experiment that the wave front could be located to within about 0.001 ft, it follows that s must be at least 0.1 ft and $2a$ should be about 55 ft.

EFFECT OF A PRESSURE GRADIENT

In incompressible-fluid flow the mean velocity at one cross section of the pipe is the same as that at any other cross section. For compressible fluids, however, a pressure gradient is invariably accompanied by a velocity gradient. One is then confronted with the necessity for choosing a certain section of the pipe at which the velocity is to be determined. And in any event the thing of primary importance is the determination of the quantity rate of delivery of the gas, which necessitates a

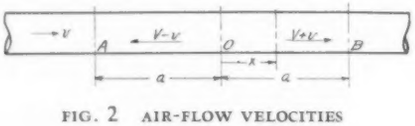

FIG. 2 AIR-FLOW VELOCITIES

knowledge not only of the mean velocity but of the mean density as well. To obtain the density it would be necessary to measure the temperature and pressure at the section. It will now be shown that the effect of pressure and velocity gradients may be ignored when the method under discussion is applied to measurements in a suitable velocity range.

Suppose that by reason of friction in the pipe and expansibility of the fluid the velocity v increases uniformly from section A to B, Fig. 2. Then the velocity at x may be taken as $v_x = v_0 + kx$, where v_0 is the velocity for $x = 0$. The times which are required for the pulses to travel from O to A and O to B are

$$t_2 = \int_{-a}^{0} \frac{dx}{V - v_0 - kx} = \frac{1}{k} \log \left(1 + \frac{ka}{V - v_0}\right) = \frac{a}{V - v_0} - \frac{ka^2}{2a(V - v_0)^2} + \ldots$$

and

$$t_1 = \int_{0}^{a} \frac{dx}{V + v_0 + kx} = \frac{1}{k} \log \left(1 + \frac{ka}{V + v_0}\right) = \frac{a}{V + v_0} - \frac{ka^2}{2(V + v_0)^2} + \ldots$$

Whence, when v_0 is small compared with V

$$\Delta t = t_2 - t_1 = (2av_0/V^2)[1 - (ka/V)]$$

and

$$v_0 = Vs/\{2a[1 - (ka/V)]\} \quad \ldots\ldots\ldots\ldots [3]$$

If $k = 0$, that is if the fluid velocity is everywhere equal to v_0, Equation [3] reduces to Equation [2] as is to be expected.

Now suppose as an extreme case, that the pipe diameter is as small as the smallest used in these experiments, namely 0.3 in., and that the velocity of air through the pipe is as large as 20 fps. Then the pressure gradient at room temperature is not larger than 0.02 ft of water per ft length of pipe.[2] To find the velocity gradient k it is observed that $P_A v_A = P_B v_B$ where P_A, v_A, P_B, and v_B are the pressures and velocities at pipe sections A and B, respectively. Whence

$$(P_A - P_B)/P_B = (v_B - v_A)/v_A$$

and if sections A and B are taken 1 ft apart, $P_A - P_B = 0.02$ ft, and at atmospheric pressure $P_B = 34$ ft, approximately.

It has been assumed that $v_A = 20$ fps, hence $k = v_B - v_A = 0.012$ fps per ft of pipe. Now the length of a is arbitrary, but if it be made 30 ft, then as has been previously shown, air velocities as low as 2 fps may be measured with a theoretical accuracy better than 1 per cent. In Equation [3]

$$ka/V = 30 \times 0.012 \div 1130 = 0.0003$$

and clearly this factor may be neglected. It may be concluded, therefore, that even though there exists a velocity gradient, the measured velocity at any cross section is not greatly affected by it, and the approximate value of v given by Equation [2] may be used with a high theoretical accuracy.

APPARATUS AND METHOD OF TEST

Two separate sound-velocity-meter ng arrangements were set up, one intended for low and the other for high velocities, both of which followed the pattern shown in Fig. 1. In each case a water displacement gasometer of 5 cu ft capacity manufactured by the Griffin Company of Philadelphia, Pa., was employed to propel the air through the metering device and also to furnish a check on the average velocity of flow. The gasometer tank was first carefully calibrated by filling it with water, removing successive increments of $^1/_4$ cu ft as determined by the weight of the removed water corrected for temperature, and measuring the successive heights of water in the tank with an accurate hook gage. The change in level per cubic foot of water was compared with the accurately measured distances between 1-cu ft marks of the gasometer scale. It was found necessary to multiply the volume as indicated on the gasome-

[2] Kent's Mechanical Engineers' Handbook, John Wiley & Sons, Inc., New York, N. Y., eleventh edition, vol. 2, Power, section 1, p. 18, Equation 24.

ter scale by 1.0072 to obtain the correct volume. The number is very nearly the ratio of the volume of a given mass of air at atmospheric pressure to its volume under the pressure increased by 3 in. of water.

After assembling the gasometer, tests were made of the steadiness of its operation. It was found by timing the descent or ascent of the holder with a stop watch that for suitable velocities the operation was very steady.

Several lengths of $1^1/_4$-in. steel electric conduit with an average inside diameter of 1.37 in. were joined by means of threaded couplings. The pipe ends were carefully butted, and the joints sealed with white lead. Referring to Fig. 1, the length $2a$, that is from 2 to 2′ measured between threaded entrance nipples was found to be 39.65 ft, center to center. Exactly half way between these nipples a sound-inlet nipple was inserted. The isolation membranes shown consisted of thin aluminum disks which were held airtight between recessed brass housings. The telescoping tube, scale, and receiver R_1 were mounted as a unit, and a rack-and-pinion device enabled the position of the tube to be adjusted easily and precisely. To prevent sounds generated in the frame of the receiver R_3 from being transmitted through the pipe a short rubber hose connection was inserted between R_3 and M_3.

Preliminary measurements indicated that the circuit employing gas-filled electronic tubes was capable of distinguishing which of two electrical impulses arrived first when one led the other by as little as one ten-millionth part of a second. Indeed in the normal course of the experiment shifting the pointer of the telescoping tube to the left or right of the zero position by 0.01 in. was sufficient to cause the needle N of the differential galvanometer to change its indications from one side to the other. As constructed the resolving power of the electronic-tube circuit was greater than the accuracy of setting the telescoping-tube pointer.

Air-velocity determinations were conducted on several successive days. The air velocity was produced in the measuring tube either by drawing air into the gasometer or by expelling it The zero position of the telescoping tube was determined as before described, and the shifts in the position of this tube were measured in each case from the zero position which was determined in still air before each velocity run. In computing, it was assumed that the velocity of sound propagation in air at temperature T, in degrees Centigrade, is given by the formula

$$V = 1089[(273 + T)/273]^{1/2}$$

It is known that relative humidity does not affect this velocity appreciably, and consequently no correction was made for humidity. While these experiments were in progress measurements of the velocity of sound propagation in pipes were made by an independent observer and found to check closely with the values computed from this formula. From the observed shift and the velocity of sound propagation the air velocity was computed using Equation [2]. Typical results obtained using the $1^1/_4$-in. pipe are shown in Table 1.

With the $1^1/_4$-in. pipe the largest velocity conveniently measureable was about 11 fps. The accuracy of measuring higher velocities was limited by the shortness of the time of travel of the gasometer holder and the error in measuring this time. In order to produce higher velocities a second smaller sound-velocity pipe was assembled. Referring to Fig. 1 the length $2a$ in this case was 10 ft and the inside diameter of the pipe was 0.293 in.

In order to develop sufficient pressure difference between the ends of the smaller pipe, it was found necessary to draw the air into the gasometer since its behavior was unstable when the holder was loaded with the large weights necessary. Results obtained with the smaller pipe are shown in Table 2.

In spite of the higher velocities in the smaller pipe the corresponding telescope-tube positions were very definite and exceptionally sharp. It is evident from Tables 1 and 2 that the

TABLE 1 AIR VELOCITIES IN FEET PER SECOND

Air expelled from gasometer			Air drawn into gasometer		
Sound-velocity method	Gasometer method	Error, per cent	Sound-velocity method	Gasometer method	Error, per cent
2.66	2.69	−1.1	2.86	2.82	+1.4
2.65	2.69	−1.5	2.86	2.84	+0.7
2.22	2.22	0.0	2.86	2.83	+1.1
2.22	2.23	−0.5	1.83	1.73	+5.5
3.38	3.38	0.0	1.76	1.73	+1.7
3.40	3.38	+0.6	1.76	1.74	+1.2
4.90	4.90	0.0	2.40	2.38	+0.8
4.85	4.90	−1.0	3.14	3.18	−1.3
6.47	6.52	−0.8	....	....	....
6.47	6.53	−0.9	3.88	3.93	−1.3
7.25	7.37	−1.7	7.53	7.45	+1.1
7.25	7.40	−2.0	6.18	6.16	+0.3
11.45	11.40	+0.4	....	....	....

TABLE 2 AIR VELOCITIES IN FEET PER SECOND

Sound-velocity method	Gasometer method	Error, per cent
22.8	22.6	+0.9
22.7	22.5	+0.9
16.4	16.0	+2.5

results are affected by small systematic errors. The source of these errors is unknown but it is believed that they arise as the result of the difficulty in estimating the volume corrections to be made in the operation of the gasometer.

DISCUSSION AND CONCLUSION

The air velocities which were measured by the two methods are for the most part in excellent agreement. In view of the departure from the stream-line and uniform-flow conditions assumed in the derivation of the velocity formula, this result may seem surprising. It is well known from Pitot-tube measurements[3] that the fluid velocity is not uniform across the section of a pipe, but is smaller at the boundary than in the inner portions. Consequently, one would expect that the first arrival of a sound pulse would depend on the maximum fluid velocity when the pulse travels in the same direction as the fluid and on the minimum fluid velocity when it travels in the opposite direction. When this is examined mathematically, it is found that these differences in the times of travel largely offset each other in the final expression for the average fluid velocity so that nevertheless Equation [2] holds quite closely for low velocities. In any event, the velocity values as actually measured indicate that Equation [2] holds remarkably well.

It may therefore be concluded that the sound-velocity meter measures, without the necessity of calibration, an average air velocity which agrees with the velocity as determined by the use of a gasometer. This suggests that it may be substituted for the more bulky, expensive, and intractable gasometer. However, further experimentation including a wider range of pipe sizes and air velocities is necessary to establish this point more generally.

In conclusion acknowledgment is made of a grant in aid, by the Engineering Foundation through The American Society of Mechanical Engineers. The experimental work was conducted in the laboratories of the Institute of Technology at the University of Minnesota.

[3] "The Mechanical Viscosity of Fluids," by T. E. Stanton, Proceedings of the Royal Society of London, series A, vol. 85, 1911, p. 366.

STEAM-TURBINE EFFICIENCIES

Computation of Performance of Back-Pressure, Extraction, and Other Types of Machines, Including Over-All Efficiencies, When Used in Combination With Heating Systems

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GUARANTEES of performance of back-pressure, extraction, and other types of steam turbines, including over-all efficiencies resulting when these machines are used in connection with heating systems, are usually based on steam flow. In the case of the extraction turbine considered alone, for example, the guarantee for one of the specified operating conditions usually states in effect:

With the turbine sustaining a specified output and with exhaust pressure not more than that specified, and when a specified flow of steam is extracted at a specified pressure, the flow to the turbine at specified pressure and temperature as measured upstream of the throttle valve will not exceed a stated quantity.

This method of expressing performance is not particularly illuminating. It serves for comparing guarantees made under identical operating conditions. It does not serve, without some computation, for comparing one turbine with another operating under slightly different conditions. It does not disclose the performance of a turbine operating under extraction conditions that are not the same as those of the guarantee, or of one operating with a variety of extraction flows or none at all. It does not indicate the quality of the turbine. For these reasons the consensus of opinion appears to be that the performance of a turbine of these types is best expressed as an "engine efficiency;"[1] in other words, the ratio of the work obtained to the work available under the operating conditions. An expression of performance based on flow, as in the foregoing, is, however, easily translated into engine efficiency.

The engine efficiency of a simple back-pressure turbine is

$$\eta = \frac{W(h_1 - h_3)}{W(h_1 - h_{s2})} = \frac{3412.7\ P_i}{W(h_1 - h_{s2})} \quad [1]$$

in which

W = steam flow, lb per hr
h_1 = enthalpy of initial steam, Btu per lb
h_{s2} = enthalpy at entropy of point 1 (Fig. 1), Btu per lb
h_3 = enthalpy (actual) corresponding to point 3 (Fig. 1), or at the point of extraction in the case of an extraction turbine, Btu per lb
P_i = $W(h_1 - h_3)/3412.7$ = internal output, that is, the power delivered by the blades to the turbine rotor, kw. Generally it is the generator output P_g that is considered
P_g = P_i minus mechanical and generator losses

The engine efficiency of a simple extraction turbine with extraction at a single point 3, Fig. 2, is

$$\eta = \frac{W_1(h_1 - h_3) + W_2(h_1 - h_5)}{W_1(h_1 - h_{s2}) + W_2(h_1 - h_{s4})} \quad [2]$$

in which

W_1 = flow of extracted steam, lb per hr
W_2 = flow of steam to condenser, lb per hr
h_5 = enthalpy (actual) corresponding to exhaust steam to condenser
h_{s4} = enthalpy corresponding to exhaust steam to condenser at the entropy of point 1, Fig. 2

The numerator of Equation [2] is equal to the internal output, $3412.7\ P_i$.

These engine efficiencies are no more nor less than the reciprocals of the heat rate, in which the turbines are charged with

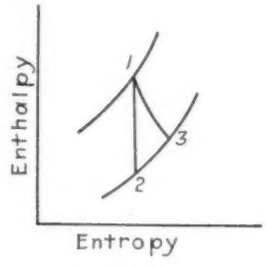

FIG. 1

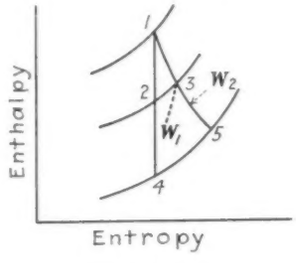

FIG. 2

the sum of the isentropic enthalpy drops. Applied to the conditions of Fig. 2, this isentropic heat rate is

$$\frac{W_1(h_1 - h_{s2}) + W_2(h_1 - h_{s4})}{P}$$

This method of expression is objectionable because of confusion between this kind of heat rate and the conventional one in which a simple power unit is credited with the enthalpy of saturated water corresponding to the exhaust pressure, or, in the case of the regenerative turbine, the enthalpy of the water leaving the final feedwater heater, with allowance for condensate temperature depression, if any, and for the work and losses of the feed pump, if one is used between the condenser and the final feedwater heater.[2]

The performance of a regenerative turbine, however, may be expressed as an engine efficiency if the pressures and quantities of flow at the points of extraction are known. This value reflects the quality of the turbine itself without reference to the performance of the feedwater heaters, condenser, and feed pump.

DARRIEUS' METHOD OF COMPARING TURBINE PERFORMANCE

Georges Darrieus, of France, proposed some years ago[3] a method of expressing the performance of any extraction, mixed-pressure, or reheating turbine, or a combination of them. He contemplated the method as a means of making a fair compari-

[1] A.S.M.E. Power Test Code on Definitions and Values, June, 1931.

[2] A.S.M.E. Power Test Code for Steam Turbines, revision under way.

[3] "The Rational Definition of Steam Turbine Efficiencies," by G. Darrieus, *Engineering*, Sept. 5, 1930, pp. 283–285.

son of turbines of any type or combination of types operating under different conditions in which the turbine alone is considered and not what is done with the exhaust or extracted steam. His method is held in high esteem in France.

M. Darrieus assumes that the available work is that resulting from isentropic expansion down to the temperature of the surroundings, which he takes as 27 C (80.6 F). He charges any heat supplied to the turbine as $W(h_1 - T_0 s_1)$, in which h_1 is the

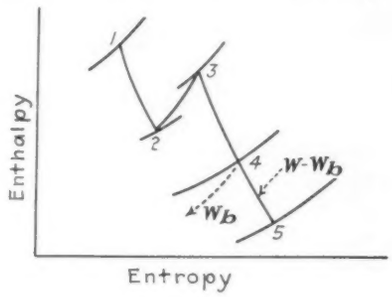

FIG. 3

enthalpy of the supply, T_0 the absolute temperature 300 C, and s_1 the entropy corresponding to h_1.

In the case, say, of a reheating turbine, Fig. 3, with one stage of extraction, the turbine is charged with

$$W(h_1 - T_0 s_1) + W(h_3 - T_0 s_3)$$

and is credited with

$$W(h_2 - T_0 s_2) + W_b(h_4 - T_0 s_4) + (W - W_b)(h_5 - T_0 s_5)$$

The internal work obtained is

$$3412.7 P_i = W(h_1 - h_2) + W(h_3 - h_4) + (W - W_b)(h_4 - h_5) \quad \ldots\ldots\ldots [3]$$

The foregoing will be clearer if a numerical example involving the simple extraction turbine of Fig. 2 is considered. Assume that the engine efficiency of the turbine steam path is 0.80, and that

p_1 = 400 lb per sq in.
t_1 = 800 F
h_1 = initial enthalpy, 1416.4 Btu per lb
p_3 = pressure at point of extraction, 50 lb per sq in.
p_5 = pressure at exhaust, 1 in. Hg abs
t_0 = 79 F
T_0 = 538.7 F
W_1 = extracted steam flow, 400 lb per hr
W_2 = steam flow to condenser, 600 lb per hr
$W_1 + W_2$ = steam supplied, 1000 lb per hr

TABLE 1 VALUES ASSUMED FOR FIG. 2

	p	t	s	h	$T_0 s$	$h - T_0 s$
At initial point (1)....	400	800	1.6842	1416.4	907.4	509.1
At extraction point (2)	50	406	1.7385	1238.2	936.5	301.7
At exhaust point.....	1 in.	79	1.8738	1007.4	1009.4	— 2.0

NOTE: The last value in the last column is negative because $T_0 s$ is greater than h_5.

Using the values from Table 1 and Darrieus' method, we debit the turbine with the heat in the initial steam 1000 × 509.1 = 509100 Btu, and credit it with the sum of the quantities in the extracted steam 400 × 301.7 = 120680 Btu and in the exhaust 600 × — 2 = — 1200 Btu; hence the balance chargeable to the turbine is 509100 — (120680 — 1200) = 389620 Btu. The work obtained in the turbine $3412.7 P_i$ is 1000(1416.4 — 1238.4) + 600(1238.2 — 1007.4) = 316680 Btu. Hence the efficiency as computed by the Darrieus method is

$$\eta_{\text{Darrieus}} = 316680/389620 = 0.813$$

By assumption the engine efficiency is 0.80.

M. Darrieus' method of expressing efficiency does not seem lucid; it gives a slightly higher value than the engine efficiency. The engineer is principally interested in the ratio of what he gets to what he would get under the limitations of the operating conditions if the apparatus were ideal; in other words, he is interested in the engine efficiency. It seems, therefore, that the method of expressing the performance of these types of turbines by means of the engine efficiency is to be preferred. Furthermore, it has the advantage of easy comprehension. It may be quickly determined from the Mo.lier diagram. It is a value that is prominent in the mind of the designer of the steam path and his ultimate aim is to obtain a high value. It is the best measure of the quality of the turbine.

EFFICIENCIES OF TURBINES COMBINED WITH HEATING SYSTEMS

In the case of a power plant combined with a heating system, the higher the efficiency of the power unit the higher will be the over-all efficiency of the system under any circumstances. The highest over-all efficiency is attained, other things being equal, when all the steam is condensed in the heating system.

If heat and work are regarded as equivalent, the efficiency of a steam power plant combined with a heating system may be defined as the ratio of what one gets out of it for use, in heat, work, or both, to what is available under the operating conditions, in heat, work, or both.

Credited to the available heating portion of the plant is the enthalpy of the water at the temperature at which it is returned to the system, provided it is so returned.

The heating-system condensate may be returned directly to the boiler at the temperature at which it leaves the heating system, which will usually be a few degrees less than the temperature corresponding to the saturated steam in the heater, because of condensate temperature depression.

If the boiler feedwater is heated by the heating-system condensate by means of a heat exchanger, the credit to the available heating portion of the system will be correspondingly lowered.

If the condensate from the heating system is wasted, it is proper to credit to the available work of the heating portion of the system the enthalpy of the water at the ambient temperature, say 79 F.

The output of the heating portion of the system is the total enthalpy supplied minus the total enthalpy of the condensate leaving the heater minus radiation and leakage losses in the heater and its piping.

In the case of the simple back-pressure turbine of Fig. 1 combined with a heating system as in Fig. 4, the over-all efficiency is

$$\eta = \frac{W(h_1 - h_3) + [W(h_3 - h_{f6}) - R]}{W(h_1 - h_{s2}) + W(h_3 - h_{f7})} \quad \ldots\ldots\ldots [4]$$

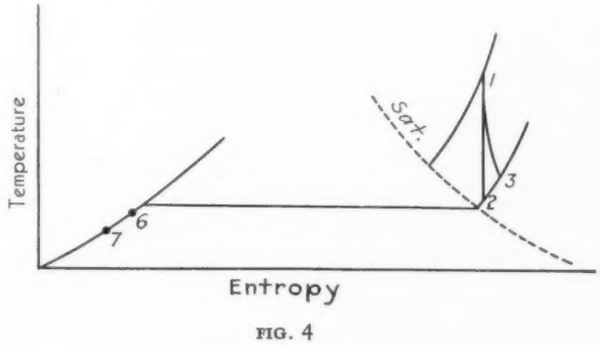

FIG. 4

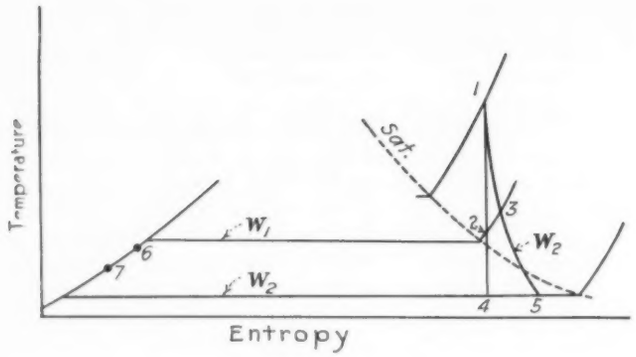

FIG. 5

in which

h_{f6} = enthalpy of water corresponding to the temperature at which it leaves the heating portion of the system, Btu per lb

h_{f7} = enthalpy of water corresponding to the temperature at which it is returned to the system, or to the ambient temperature if the heater condensate is wasted, Btu per lb. The value depends upon the use made of the heat in the condensate

R = radiation and leakage loss in the heating portion of the system and its connecting piping, Btu per hr

In the case of the simple extraction turbine of Fig. 2 combined with a heating system as in Fig. 5, the over-all efficiency is

$$\eta = \frac{W_1(h_1 - h_3) + [W_1(h_3 - h_{f6}) - R] + W_2(h_1 - h_5)}{W_1(h_1 - h_{s2}) + W_1(h_3 - h_{f7}) + W_2(h_1 - h_{s4})} \quad [5]$$

in which

W_1 = steam extracted, lb per hr

W_2 = steam flow to condenser, lb per hr

h_{s4} = enthalpy of exhaust steam following isentropic expansion from h_1, i.e., at entropy s_1, Btu per lb

h_5 = enthalpy (actual) of exhaust steam, Btu per lb

The foregoing efficiencies are exclusive of boiler losses and any essential auxiliaries required for such services as pumping condensate, and are exclusive of allowances for turbine-gland flows,[4] which are properly included.

COST OF BY-PRODUCT POWER

In the foregoing cases of a turbine operating in combination with a heating system, the power obtained may be regarded as by-product power. It is interesting to note the cost of this power based on thermodynamic accounting.

In the case of the back-pressure turbine and the heating system of Fig. 4, the ratio of internal power obtained to the total work (internal power plus heating) obtained is

$$\frac{W(h_1 - h_3)}{W(h_1 - h_3) + W(h_3 - h_{f6}) - R}$$

The total available work is

$$W(h_1 - h_{f7})$$

The heat rate at which by-product power is obtained is

$$\frac{W(h_1 - h_{f7}) \times \dfrac{W(h_1 - h_3)}{W(h_1 - h_3) + [W(h_3 - h_{f6}) - R]}}{\dfrac{W(h_1 - h_3)}{3412.7}} \text{ Btu per internal kw}$$

[4] A.S.M.E. Power Test Code for Steam Turbines, revision under way.

In the case of the extraction turbine and the heating system of Fig. 5 the ratio of internal power obtained to the total work obtained is

$$\frac{W_1(h_1 - h_3) + W_2(h_1 - h_5)}{W_1(h_1 - h_3) + [W_1(h_3 - h_{f6}) - R] + W_2(h_1 - h_5)}$$

The total available work is

$$W_1(h_1 - h_{f7}) + W_2(h_1 - h_{s4})$$

The heat rate at which by-product power is obtained is

$$\frac{W_1(h_1 - h_{f7}) + W_2(h_1 - h_{s4}) \times \dfrac{W_1(h_1 - h_3) + W_2(h_1 - h_5)}{W_1(h_1 - h_3) + [W_1(h_3 - h_{f6}) - R] + W_2(h_1 - h_5)}}{\dfrac{W_1(h_1 - h_3) + W_2(h_1 - h_5)}{3412.7}} \text{ Btu per internal kw}$$

Table 2 gives calculated numerical results of back-pressure and extraction turbines operating in conjunction with heating systems and based upon the following assumed operating conditions:

Initial pressure, lb per sq in.	400
Initial temperature, F.	800
Initial enthalpy, h_1, Btu per lb.	1416.4
Initial entropy, s_1.	1.6842
Back pressure or pressure at point of extraction, p_2 or p_3, lb per sq in.	50
Exhaust pressure to condenser, p_4 or p_5, in. Hg abs.	1
Assumed engine efficiency of turbine steam path.	0.80
Enthalpy at p_2, constant entropy s_1, h_{s2}, Btu per lb.	1193.6
Enthalpy (actual) at p_3, h_3, Btu per lb.	1238.2
Entropy at p_3, s_3.	1.7335
Enthalpy at exhaust to condenser, constant entropy, s_1, h_{s4}, Btu per lb.	905.2
Enthalpy (actual) exhaust to condenser, h_5, Btu per lb.	1007.4
Enthalpy of water leaving heating system when returned directly to boiler, temperature assumed 20 F less than temperature of saturated steam in heater, 261 F, h_{f6}, Btu per lb.	229.7
Enthalpy of water to be credited to system when the heating-system condensate is wasted, taken at ambient temperature 79 F, Btu per lb (h_{f7}).	47.0
Radiation and leakage from heating system, R, per cent.	5.0
Total steam flow to extraction turbine, W, lb per hr.	1000
Extracted steam flow, W_1, lb per hr.	400
Steam flow to condenser, W_2, lb per hr.	600

TABLE 2 OVER-ALL EFFICIENCIES AND COST OF BY-PRODUCT POWER FOR A BACK-PRESSURE TURBINE AND AN EXTRACTION TURBINE COMBINED WITH A HEATING SYSTEM

	Over-all efficiency	Cost of by-product power based on thermodynamic accounting, Btu per internal kw
Back-pressure turbine and heating system, Fig. 4, heating-system condensate returned to boiler at h_{f6}.	0.923	3564
Same, heater condensate wasted at h_{f7}.	0.804	4113
Extraction turbine and heating system, Fig. 5, when heating system condensate is returned to boiler at h_{f6}.	0.876	3810
Same, heater condensate wasted at h_{f7}.	0.802	4166

NOTE: No allowances have been made for boiler, turbine, mechanical, and electrical losses or for extraneous flow from turbine glands or any essential auxiliaries necessary for pumping condensate.

HISTORY *of* SCIENTIFIC MANAGEMENT *in* AMERICA

Prepared by the American History Committee[1] for the 1938 International Management Congress

SCIENTIFIC MANAGEMENT in America is one of the most potent factors in the industrial development leading to low production costs and a higher standard of living.

As a historical and practical development, scientific management is the utilization of policies and methods derived from analysis of all of the facts which bear upon a managerial situation. It involves research for the factual determination of policies and methods, standardization of the requisite practices, control of the procedures involved in the use of standards, and cooperation of all individuals associated with the activity.

In its early days, the technique of scientific management involved a certain amount of "scaffolding" while new procedures and routines were being installed. Experience resulting from the widespread adoption of the technique, however, has lessened the necessity of this scaffolding so that gradually it is being superseded by methods based on the fundamental principles rather than on routine procedures.

Scientific management is destined for a broader field of application in the solution of problems relating to the stabilization of an economy.

FIRST SCIENTIFIC MANAGEMENT IN INDUSTRIAL PLANT

Scientific management in manufacturing actually began, from the standpoint of practical operation, but little more than fifty years ago in the plant of the Midvale Steel Company, Philadelphia, through the initiative of Frederick W. Taylor.

It is recognized that previously certain elements in management had been developed by the scientific method. Notably in France as far back as the eighteenth century there had been beginnings of the measurement of effort and fatigue in muscular operation with some utilization in actual practice. Piecework, with tasks based on analysis of past experience, had been used. Certain forms of wage payments involving premium and wage sharing had been worked out both in America and abroad. But these earlier efforts were casual and had practically no influence on industry generally. As the French engineer, Charles de Freminville, has put it, it was Taylor who first applied the inductive method to study of the problems of factory management and later to study of problems of general administrative management.

Scientific management as it originated at Midvale in the 1880's, although in all respects rudimentary, embraced completely the fundamentals of scientific shop management. It promptly integrated research, standardization, and control into an adaptable scheme of managing. While inspired by the purpose of making the facts governing production available for settlement of disputes with workers, supplemented by the desire for larger productivity to reduce cost of the product, it was recognized almost immediately that to attain this with fairness to the worker, the problem involved all phases of management which influence the quantity and the quality of the product turned out. Taylor therefore started experimental studies to obtain the knowledge required to set fair and acceptable standards for the workers, and out of these studies grew the developments that involved functional operation, production control, inventory control, and the various other features which have gradually established themselves in almost universal practice.

For example, when the setting of piece rates was considered at Midvale, it was found that the major factors governing productivity and quality were beyond the workers' control, that these were, in fact, functions of management. To obtain fair standards which would be equitable to the different workmen and to the same workmen at different times and on different jobs, it was necessary first for management to bring these factors under control.

It was therefore found necessary to plan the work systematically so as to eliminate lost time waiting for work; to provide the workman with proper tools; to show him the experimentally determined proper speeds for his machine; to standardize the belting to drive at the required speeds without breakdown; to work out with the workman the best method of performing each operation; to develop standards of method and mechanism; to institute research in procedure and equipment; to analyze materials; to develop specifications; and finally, to develop the methods of determining of standard times of performance through the use of elementary or unit times as distinguished from over-all times.

Unit time study—in principle, the control of the variables of a problem—was one of the most momentous of Taylor's many discoveries in the field of procedure. Its importance was overlooked and even today is not utilized with complete effectiveness. By determining the time for each element of an operation it is possible to recombine these to fit innumerable other operations. For example, it permits set-up time on a machine, which occurs once in each job on the machine and does not vary with the number of pieces, to be separated from operating time, which does vary with the number of pieces, so that it is possible to determine the time required for new jobs without new time studies. It permits multitudes of unit-time combinations for different operations. It is the essential basis of planning; especially of scheduling.

All of these fundamentals were developed by Taylor previous to 1890. During the succeeding five years were developed improved methods of inventory control, including the "balance-of-stores" or running inventories which, modified to meet present conditions, are now in almost universal use; functional control, involving the assignment of specific phases of management to different men; the mnemonic system of classification; and more scientific methods of accounting, now recognized as the basis of the most advanced modern cost accounting.

Next came the rounding out of the technique: The invention

[1] Henry S. Dennison, president, Dennison Manufacturing Co.; Henry P. Dutton, dean, Evening School, Armour Institute of Technology; Henry P. Kendall, president, Kendall Company; Harlow S. Person; and Sanford E. Thompson, president, Thompson and Lichtner Co., Inc., engineers, *Chairman*.

of the decimal dial stop watch, the working out of the shop slide rules, the development of production control, and the means for maintaining quality production. All of these were fairly well rounded out by 1905.

Micromotion study, originated and developed by the late Frank B. Gilbreth, is an excellent example of a valuable refinement of time and motion study now frequently used as a feature in the technique of scientific management.

While of course more recent developments of shop management have modified the mechanisms employed in the early days, the principles and fundamental mechanisms are in general use by industry today not only in production, but also to a considerable extent in marketing and in general administrative control.

CALENDAR OF SCIENTIFIC SHOP-MANAGEMENT DEVELOPMENTS

The progress of development may be presented roughly in ten-year periods:

(1) 1875–1885 A groping for better methods of management, and the beginning of scientific management
(2) 1885–1895 Development of the fundamentals of scientific shop management
(3) 1895–1905 Rounding out the basic technique
(4) 1905–1915 Expositions of scientific managment to the world
(5) 1915–1925 Collateral development by inrushing converts of rigid "efficiency" schemes and certain oversystematization with loss of due perspective and disregard for analytic studies
(6) 1925–1935 Normal and sound development in the shop and acceptance by trade unions.

Gradually during these later periods came the acceptance of the scientific factual approach to the various problems of personnel, marketing, and general administrative functions.

EARLY PRACTICAL DEVELOPMENT OF SHOP MANAGEMENT

The importance of the early applications which led the way to the broader developments of the present day cannot be overestimated.

That a description of these undertakings is largely an account of the work of Frederick W. Taylor is due simply to the fact that during these early days—certainly until after the beginning of the present century—there were no published or extensive developments of method in manufacturing that could be termed scientific other than those with which Taylor was associated as the master mind.

In William Sellers Company, the functional principle in management was recognized as early as 1876 in allocating the grinding of machine tools to a separate department instead of having each machine operator grind his own tools. This plan resulted from the recognition of the importance of the shape of the tool in quality and quantity production.

The fundamental principles of shop management are predicated on the solutions of the problems worked out at the Midvale Steel Company between 1880 and 1888, as has been described in previous paragraphs. During the decade following, the principles were definitely formulated.

From 1888 to 1892 was a period of slow development during which scientific methods were applied for the first time in an industry other than metalworking. In the sulphite pulp plant of the Manufacturing Investment Company in Wisconsin the production methods were well organized. Then followed a year in which Taylor, with a vision of the opportunities for science in industry, devoted himself in seclusion to the development of methods of planning and of cost accounting. He was then ready to begin business as the first management engineer.

In the Simonds Rolling Machine Company, 1893–1894, certain scientific methods were introduced, including belting control, running inventory control with the balance-of-stores sheets, unit time studies, and, in material research, continuous hardening of steel balls.

During the same period, Taylor instigated a scientific study of the building trades with the purpose of developing standards of production in this field of multitudinous variables which would increase output, reduce costs, and give higher earnings to the workers. The application of the principles and their practical utilization in one branch of construction is presented in the book "Concrete Costs," by Frederick W. Taylor and Sanford E. Thompson, published in 1912. In the course of this research by Mr. Taylor and his associate, Mr. Thompson originated the decimal dial stop watch now in universal use in industry. These construction studies were continued for the next fifteen years although the results have not yet been utilized to any great extent because of the backwardness of builders and of workmen in appreciating the fundamental importance of a knowledge of a day's work in lowering costs and raising the standard of living.

Other partial installation by Taylor of shop management and of cost accounting followed the Simonds Rolling Machine Company work; at Johnson Company and Loraine Steel Company, Cramps Shipbuilding Company, and then in 1898–1901 the Bethlehem Steel Company. In all of these the work was handicapped by the resistance of management and of plant executives to change and to the revolutionary nature of the philosophy and technique involved.

At the Bethlehem Steel Company were finally consummated the metal-working experiments which Taylor had been carrying on in different establishments for twenty years. These were perhaps the earliest application of prolonged scientific research to a manufacturing problem, and led to the development of the Taylor-White high-speed steel.

In 1903 were begun the comprehensive developments in the plants of the Tabor Manufacturing Company and the Link Belt Engineering Company, where were first introduced as an integrated whole the methods and technique of planning, scheduling, inventory control, and the various other phases of scientific shop management.

In the later years of the first decade of this century the chief engineer officers both of the Navy and the Army became interested in scientific methods of shop operation and were able to improve production methods and increase productivity in the Navy yards and arsenals to a remarkable degree, and at the same time increase the earnings of the workers. Lack of appreciation on the part of certain labor leaders and of misinformed students of social problems caused the passage by Congress in 1914 of the rider to appropriation bills prohibiting the use of the stop watch in manufacture of ordnance. This resulted in unforeseen handicaps to production of war material for the World War.

While there had been much excellent work by those who appreciate the scientific method, and by many imitators, Frederick W. Taylor is recognized as "the father of scientific management." But it must be emphasized that while these early developments produced a technique and principles of management of permanent significance, the technique, as stated in our introduction, has naturally grown and changed from the "scaffolding" necessary in the initial stage, and the principles have taken on a broader meaning and utilization. The remarkable fact remains that all the basic technique and even a large part of the original technique is used daily in most of the well-established plants in America. In many, perhaps in the majority, this is done with no appreciation of the source of the methods. Unit time study, planning, scheduling, inventory

control, functional organization, and other features are utilized in principle and in practice. And yet on the other hand the practice of basing decisions on snap judgment or superficial comparison is still far too common both among manufacturers and those who term themselves management engineers.

Several men who were associated with Taylor during the early years of the development of scientific management, namely, 1890 to 1905, contributed to its technique and practical application. Carl G. Barth, with his brilliant use of mathematics in research and his knowledge of machine tools, devised a number of special slide rules for the solution of machine-shop problems. Henry L. Gantt, of broad education in economics and engineering, developed the wage plan of a bonus with guaranteed day wage and contributed in the smoothing out of Taylor mechanisms in action. H. King Hathaway, with the assistance of Carl Barth, made one of the earlier and more complete practical applications of Taylor's methods of planned control at the Tabor Manufacturing Company. Many others have made important contributions since 1905.

PUBLICITY

Early writings in America with any direct bearing on the scientific phases of shop management were the papers by Henry R. Towne on "The Engineer as Economist," in 1886, and "Gain Sharing," in 1889, and the paper in 1891 on "The Premium Plan of Paying for Labor," by Frederick A. Halsey, all before The American Society of Mechanical Engineers. These suggested a new form of wage payment which added to the daily wage a premium, based on a division between management and the workman, of savings resulting from speedier work but with no scientific research to obtain a knowledge of the proper times of performance. Even previous to these papers was published in 1885 the book "Cost of Manufacturing," by Capt. Henry Metcalf describing a card system of shop returns introduced at Frankford Arsenal.

The first description of the principles involved in scientific management were Frederick W. Taylor's "A Piece Rate System, Being a Partial Solution of the Labor Problem" in 1895, before The American Society of Mechanical Engineers. This paper was epoch-making as the first presentation of a scientific method based on thorough studies of times of unit operations for combining elementary times—as a chemical formula combines the molecular symbols—to fit different operations.

In "Shop Management" (1903), presented before the same Society and later published in book form, the principles outlined in the earlier paper were broadened to cover the scope of work in the plant. Then finally in 1911 came the "Principles of Scientific Management" which treated the subject in its general applications from a popular philosophical standpoint. In his introduction to this book Taylor notes that the illustrations will especially appeal to engineers and managers of industrial and manufacturing establishments, and to all of the men working in these establishments. He then adds the prophecy: "It is hoped, however, that it will be clear to other readers that the same principles can be applied with equal force to all social activities: to the management of our homes; the management of our farms; the management of the business of our tradesmen, large and small; of our churches, our philanthropic institutions, our universities, and our governmental departments."

A paper almost as scientific as these papers on scientific management applied to shop procedure, was the paper "On the Art of Cutting Metals" presented by Taylor in 1906 to The American Society of Mechanical Engineers as a presidential address. Not only does this treatise describe the development of high-speed steel through a research then unparalleled in the field of mechanical engineering, but it analyzes all of the practical problems of metal cutting such as composition of steel, hardness, shape of tool, and depth of cut.

Each of these papers was presented to a limited audience. General publicity through articles in magazines did not appear until 1910. These at first described Taylor and his methods in popular fashion. Then followed a multitude of expositions, some favorable and others derogatory and even virulent. The fact that anything relating to industry or business could be "scientific" was particularly abhorrent to some writers.

A sensational event, which occurred about this time and brought scientific management to world attention, was the statement by Harrington Emerson, brought out by Louis Brandeis, at that time attorney in the famous railroad rate cases of 1910–1911 and subsequently a Justice of the Supreme Court, to the effect that the railroads could save through scientific management $1,000,000 per day. This statement caused an uproar, but Brandeis' masterly analysis of the principles of scientific management in his brief was scarcely noticed.

An important stage in the history of scientific management was the Conference on Scientific Management at Amos Tuck School of Dartmouth College in 1911 under the leadership of Dr. Harlow S. Person, director. Some 300 businessmen and engineers and statesmen coming from all parts of the country listened to notable addresses by Taylor and other leaders, addresses presenting basic principles of the movement, practical examples of utilization of these principles, and forecasts of the future.

ASSOCIATIONS

The year 1912 marked the launching of an association for organized discussion of Taylor's doctrines and technique of scientific management which provided a definite impetus to the movement of scientific management. The Society to Promote the Science of Management was formed by a group of men devoted to the cause of practical development of the scientific approach to managerial problems. In 1915, the year of the untimely death of Taylor, the association was renamed the "Taylor Society" in honor of the great leader. Continuing under this designation until 1934, an amalgamation of the Taylor Society and the Society of Industrial Engineers caused a revision of the title nearly to the original phrasing, namely, The Society for the Advancement of Management.

In the year of the founding of the society, 1912, the Efficiency Society was organized in New York City but was of comparatively short life because of the limited scope of its outlook and program.

Next was the Society of Industrial Engineers, organized in 1917 and designed, at the start, to supplement the work of the Taylor Society with more emphasis on production methods.

In 1919 the National Office Management Association was formed, and in the same year the National Association of Cost Accountants.

The Management Division of The American Society of Mechanical Engineers was next created in 1921.

In 1922 the American Management Association was formed as a combination of earlier groups devoted to school and corporation training and to personnel. Later the scope of the Association was broadened to embrace all branches of management.

A professional association of practicing management engineers was organized in 1929 under the designation of Association of Management Engineers.

The American Marketing Society was founded in 1931. A number of local groups and organizations have been formed in various parts of the country. Several organizations have been formed in other nations.

With the growth of these various societies working along

different and sometimes parallel lines, it was decided in 1933 by a group of men influential in the different organizations that the time was ripe for the formation of a council of the various societies under the name of the American Management Council.

Of vast international importance in the development of scientific management was the institution of the International Management Congress in 1923. This was initiated by the scientist-president, Masaryk, of Czechoslovakia, with the advice of American engineers. The congress met in Prague in 1924 and has been followed by congresses in Brussels in 1925; in Rome in 1927; in Paris in 1929; in Amsterdam in 1932; in London in 1935; and in Washington, D. C., in 1938, as the Seventh International Management Congress.

BROADER FEATURES OF SCIENTIFIC MANAGEMENT

So far in this brief history, scientific management has been treated chiefly from the standpoint of the shop. For here was the initial development. It was not until about the close of the fourth period and the date of the death of Dr. Taylor in 1915 that the breadth of the scientific approach to management of business and social problems, as already envisioned by Taylor, began to be realized.

Possibly the most important element in Taylor's contribution was the thorough demonstration he gave of the applicability of the inductive method to all industrial and business problems. The classic studies of tool feeds and speeds pointed the way to other studies in the business field. The broad result in the change-over in the psychology of a generation of businessmen from the "practical" and "empirical" to the more systematic application of experimental methods is a result which far surpasses the actual procedures developed by Taylor and his associates.

APPLIED RESEARCH AND SALES MANAGEMENT

In the summarization of scientific management, therefore, the basic position of research must not be minimized. With the earliest studies of management in the 1880's began, as a necessary phase of shop management, the far-reaching researches in materials and processes. The results in high-speed steel attained after twenty years of experimentation owed their successful conclusions to the scientific principle of "single variable" research, introduced by Taylor at the very beginning, but at that time doubtfully received by many who failed to envision the possibility of the application of the scientific method in business and social fields.

The possibility of a productive application of the scientific methods in fields even farther removed than Taylor's studies from the field of the physical and "exact" sciences has been indicated in more recent years by various applications of research methods to the personnel problems of industry. As an illustration is the research originating as a cooperative investigation of the effect of lighting. This experiment, the results of which have been substantiated by a variety of experiences among the more highly developed organizations in America, quickly led, in the case cited, to the developments of new lines of investigation. The experiment consisted originally of carrying on work for a period of months by a small experimental group of women workers. These women, performing a task identical with that of a larger control group whose work went on without alteration, were submitted to a variety of conditions which it was expected would influence output, such as change in lighting intensity, introduction of rest periods of varying duration and spacing, different systems of incentive payment, and other factors. An early result of the experiment was the emergence of the surprising fact that output apparently continued to increase regardless of the changes made in conditions. Investigators were led to the conclusion that the reaction was not, as it would have been with mechanical materials, a simple response to an individual change in environment, but a composite response which depended on the way in which the subject of the experiment viewed the reaction. The steadily increasing output, for example, traced back to the changed sentiments with which the employees regarded their work. It was no longer an unpleasant task to which they were held by a task master, but an interesting, and in so far as their feelings were concerned, a voluntary activity. This initial experiment in turn led to an extensive study of employee attitudes involving the questioning of some thousands of employees, and has caused an important modification in the company's philosophy of employee relations.

In the broader developments in the business field, the standardization of shop practices which required advance planning of production naturally led the way to improvements in sales management, since production planning must begin with definite assumptions as to sales.

Scientific methods in marketing were given little consideration until the fifth era of the foregoing calendar. In fact it was not until after the World War and the problems of a buyers' market that this important phase of management came into the picture. The tremendous excess of plants and equipment, induced by the demand for war materials, had left the country with an excess productivity capacity, and the crying need for more sales turned attention of industrialists toward the possibility of the application of the scientific method to sales as well as to manufacturing.

In scientific sales management the same principles are involved as in production. These evidence themselves in design of new products, planning production with the cooperation of the production division, improved costing, budgeting future sales, defining marketing territories, establishing quotas, and developing plans for fair remuneration to the selling forces.

LABOR RELATIONS AND GENERAL ADMINISTRATION

Labor relations or personnel relations also came into more prominent view as a specific function of management about the beginning of the fifth period, although we must again hark back to Frederick Taylor in the 1880's for the beginning, both of the divorcing of the foreman from hiring and discipline of workmen and of plans for cooperative insurance of the workers.

More direct cooperation of the workers and their organizations has been a more recent development. The American Federation of Labor in 1925 formulated and adopted their productivity theory of wages in these words: "We hold that the best interests of wage earners, as well as the whole social group, are served by increasing production in quality as well as in quantity and by high wage standards which assure sustained purchasing power to the workers and, therefore, higher national standards for the environment in which they live and the means to enjoy cultural opportunities."

For a number of years, following the early publicity, labor leaders opposed the introduction of scientific methods on the fallacious theory that increase in productivity was detrimental. Gradually this attitude has been changing as is indicated by the foregoing statement. Labor is strongly opposed, and rightly, to unscientific methods of rate setting which tend simply to speed up and do not reflect a scientific treatment of all conditions. Union-management cooperation is becoming an accomplished fact. Thoughtful labor leaders realize that when more is produced there will be more to divide.

In the general administration of a business the scientific approach to the various problems of organization and management is slowly but surely superseding the old idea that the head of a business is a czar to give imperialistic orders to all of his

subordinate officers and men. The successful executive today, instead of a "captain of industry" priding himself on his quick decisions based on his personal judgment, is one who thoroughly analyzes, through his executives, each problem that arises and bases his decision on this factual analysis.

Essential to this type of reasoning is an organization designed to plan the work ahead and lay it out so as to finance and sell and produce with a resulting profit and with continuity of employment throughout the year.

Substantial progress has been made by the application of scientific management in the field of budgeting and financial planning. The modern budget—especially the flexible forecasting budget—is an outstanding concrete evidence of scientific management in general administration. The analysis of expenses into those tending to be fixed and those variable in nature has greatly increased the accuracy of the prediction of financial requirements. With this increasing accuracy has come an increasing realization of the possibilities of budgetary control, not only as a means of estimating financial needs, but as a measure of the effectiveness of performance and the maintenance of a satisfied personnel. Accounting concepts are being increasingly influenced by economic analysis and theory. Work has been done in the analysis of inventory control, and also in quality control; and in all these cases the tendency is to reduce operating standards to direct dollars-and-cents terms, making possible the translation of all operating results into a single common denominator of cost.

Equally essential is the development of specialization not only for individual workmen but for the executive personnel. This involves the functional principle of delegation of duties to specific individuals or departments. Functional foremanship, which originated with Dr. Taylor, has become, with slight modifications of his original plan, the normal arrangement in a shop. The modification lies chiefly in making a managing executive the coordinator and clearing house for the staff instructions, inspections, and records developed by various functional departments such as engineering design, planning, time and motion study, cost, inspection, purchasing, employment and personnel, and other well-known activities.

And the functional principle has been applied in the development and organization of administration not only in industry but also in banking and in office management.

As an outgrowth of manufacturing and of general business organization has come also the more scientific layout of factories, office buildings, and banking houses.

GOVERNMENT

The rapid growth of government activities and the increasing burden of taxation have focused attention on the problem of increasing the effectiveness of governmental operations. The methods of analysis of operations found applicable in private industry have been carried over, in many cases bodily, into fields of municipal, state, and federal operation. The necessity for more effective coordinated operation of the vast activities of government is already apparent even to the general public. Few fields offer greater promise for the applications of the principles of scientific management.

PRINCIPLES OF SCIENTIFIC MANAGEMENT

A history of scientific management in America would be incomplete without further reference to fundamental principles. Frederick W. Taylor stated that: "Scientific Management, in its essence consists of a certain philosophy, which results . . . . in a combination of the four great underlying principles of management: First, the development of a true science; second, the scientific selection of the workmen; third, his scientific education and development; fourth, intimate friendly cooperation between the management and the men."

These general principles may be expressed more categorically as involving research, standardization, control, and cooperation.

RESEARCH AND STANDARDIZATION

Research is of three types, all of which come under the head of scientific management in having their foundation in the same spirit of scientific inquiry:

(*a*) *Products and Equipment*. The development of high-speed steel is an example of equipment research. The vast multitude of new manufactured materials of the present century illustrates product research.

(*b*) *Methods of Management*. Research in the individual establishment comprises a study of the best methods of operation and management involving labor, materials, products, and sales.

(*c*) *Business and Economics*. Research into broader problems of economics and business and finance and administration is essential in determining basic facts so as to correct the inequalities which produce business fluctuations and finally to result in a well-balanced standard of living.

However keen and far-reaching the research, unless the results are stabilized as standards, they are of little practical value. Products and equipment must be designed to definite specifications. Methods of manufacture, including operating times, operating methods, materials, and organization, must be clearly defined and carried through in uniform practice. Problems of business and economics must not only be solved but the conclusions must be established in practice.

CONTROL AND COOPERATION

Scientific management defines control as that which governs by logic and not by force. To maintain standards there must be developed methods of controlling the various factors as regards utilization of equipment, flow of work, general administration, and promulgation of the factual conclusions.

Any system of management which calls for predetermined acts according to standards previously established—acts which supplement and reinforce each the other—is inherently a system of management dependent on good will and cooperation.

Cooperation in the broader relationship and social developments becomes one of the most vital features of scientific progress. Cooperation is inherent in scientific management.

The application of scientific principles to methods of industries and business management has led to substantial developments in the more involved problems of society.

THE FUTURE

It was logical and inevitable that the first productive developments in scientific management should have been exceedingly specific; only by concentrating on a single field could an advance have been made over the generalized knowledge and tradition on which business was based at the time Taylor began his work. Based on the method developed in these early studies, however, a steady expansion of scope has taken place as it has been proved possible to submit one after another of the problems of business and social organization to Taylor's experimental and fact-finding procedure. Applications have already been made not only to the financial and sales problems of business, but to the organization problems of government, and it is not too much to hope that, as the technique of such applications improves, we may find in them at least a partial answer to some of the major social and political problems of the present and the immediate future.

A FLOOR UNDER WAGES: BRITISH STYLE

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UNTIL recently, minimum-wage legislation in this country had been confined to limited action on the part of individual states.[1] Due, among other things, to court interpretations, this state legislation had proceeded on a halting and circumscribed basis. It applied only to women and minors, and the legal status of enforcement with respect to the former group was at best doubtful. In 1938, with the passage of the Fair Labor Standards Act, the federal government embarked upon a broader course of regulation, applicable to men as well as to women employed in interstate commerce. This newer venture is, needless to say, still in the process of clarification and future developments are not yet entirely clear.

In the meantime, Great Britain has been gradually accumulating experience along similar lines during the last thirty years. Starting with the original Trade Boards Act of 1909, the British have modified and extended their approach to the regulation of wages and have evolved techniques of administration. The history and analysis of this experience forms the subject of a careful study, recently published, by Miss Dorothy Sells.[2] This report will well repay serious consideration by American readers, of whatever cast of opinion, who are interested in governmental regulation in the field of wages and hours.

Only the briefest summary of British methods of wage regulation can be given here. Of central importance in the scheme are the trade boards, some 49 of them in more than 40 trades. (In a few trades, there is a separate board for Scotland as well as one for England and Wales.) Each of these boards is composed of an equal number of employers and employees, plus three appointed members who have no connection with the trade in question. Although the minimum wages must be approved by the Minister of Labor, the trade boards in practice have almost complete authority to set wages at whatever level they choose. Differentials by region, by sex, by age, by occupation, and the like may be set if the board deems it advisable. Enforcement of the rates is in the hands of the Ministry. Special rates and conditions for the employment of learners and apprentices may also be prescribed by the boards.

Two developments of rather more recent origin, outside the general Trade Board Acts, may be of particular interest to American readers. In 1924, Parliament applied to agriculture a system of regulation similar to that of the trade boards in industry. Under the Agricultural Wages Regulation Act of that year autonomous local committees, set up along lines similar to those of the trade boards, fixed minimum wage rates for agricultural labor in their respective districts. It is interesting, although not entirely surprising, to note that Miss Sells finds that rather more criticism has been directed at the agricultural committees than at their counterparts in industry, and that the enforcement of the minimum wage rates has proved rather more difficult in the farming areas. In spite of certain admitted difficulties, however, the provisions were extended to Scotland in 1937; in other words, it was considered that the advantages outweighed the defects.

Another type of development which has occurred in recent years is to be found in the Cotton Manufacturing Industry Act, first passed in 1934 and renewed in 1937. Under the terms of these acts, minimum wage rates which are agreed upon by representatives of employers who control a majority of the looms in the industry and workers' organizations whose members make up more than half of those employed, may be made compulsory for the entire industry. Generalized application of these rates is dependent upon a favorable report from a special ad hoc committee appointed to consider their reasonableness. Under this procedure, it is clear, almost the whole emphasis is placed upon voluntary action within the industry in question. This bare and inadequate description of some of the outstanding features of the British system of wage regulation has been intended only to suggest the general structure which has been established.

A host of questions immediately arises. Has the legislation been effectively enforced? Has the regulation been successful? How have the laws as administered affected wages, hours, and employment? How have they affected unionism and how, in turn, have they been affected by unionism? It will be interesting to look at the conclusions at which Miss Sells has arrived on these points.

Enforcement, as might be expected, has been good. In large part, this appears to have been due to the capability and cooperative attitude of the staff of inspectors. Special attention may be called to the fact that the inspectors on occasion act as informal industrial engineers, suggesting improvements in layout or production methods that will enable a firm more easily to pay the minimum rates. It is also worthy of note that about one fifth of all establishments subject to the acts are scheduled for routine examination each year. But inspection is only a part of the explanation of enforcement in Great Britain. There is likewise a high degree of compliance on the part of employers. As Miss Sells points out (page 229), there is little deliberate violation; employers "irrespective of whether they like a law, set out to find ways which will enable them to obey it without loss, instead of calling upon their lawyers to devise safe means of evasion."

Has the regulation been successful? It is possible to seek an answer to this question in at least two ways. On the one hand, the question might be asked: Are those, both employers and employees, who are affected by the legislation satisfied with the way it has worked out? Judged on this basis, the question of success must be answered in the affirmative. Workers feel that wage rates have been increased and stabilized. Employers appreciate the advantages inherent in the removal of exploitative wage competition and in the general raising of the plane of competition, arising partly from the association engendered by the acts. Not that there have not been criticisms of the system. On the contrary, at practically all times there have been objections, and some times these objections have been sufficiently pronounced to threaten the existence of the whole structure. But adjustments have been made, the system has weathered the storms, and at the present time it seems clear that only a few isolated individuals would seriously consider scrapping the scheme.

On the other hand, criteria of success may be sought in an examination of objective evidence relating to wages, hours, and employment. Here the evidence is somewhat less conclu-

[1] With the exception of wage provisions in the NRA codes.

[2] "British Wages Boards: a Study in Industrial Democracy," by Dorothy Sells. The Brookings Institution, Washington, D. C., 1939.

One of a series of reviews of current economic literature affecting engineering prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Opinions expressed are those of the reviewer.

sive. It is possible to show, as Miss Sells does show, that wage rates in trade-board industries have increased in relation to cost of living, to wholesale prices, and to wage rates in other trades. It is likewise possible to show that unemployment in trade-board industries has not been higher than in other industries, and that possible exceptions to this statement may easily be explained on grounds other than the existence of minimum rates. Unfortunately, however, it is not possible to demonstrate that rates of wages are higher than they would have been in the absence of regulation, or that relatively low unemployment is not due to the innate characteristics of the regulated industries. A negative conclusion, at least, is probably justified: Wage regulation does not appear to have been ruinous in the trades to which it has been applied.

In England, as in this country, there have been those who have felt that a greater reliance upon governmental or quasi-governmental regulation of wages would weaken the appeal of unions to the workers. There have been others who have taken the opposite position, that the existence of governmental machinery would stimulate the organization of workers (or of employers as well). On this point also, the British experience is not conclusive. Suffice it to say that, after careful consideration, a committee of trade unionists in 1931 recommended that the trade boards be continued.

Before such comments are applied to American conditions, it should be recognized that organizations of workers and employers have played a more important part in the fixation of wages under the British acts than they seem likely to play in this country, in the immediate future at least. In the absence of a national minimum, the British trade boards have an almost unlimited scope in determining conditions in the industry. And the great majority of employer and worker members of these boards are selected by organizations on their respective sides. There is thus an incentive to effective representation on the boards, an incentive which may, in some cases, redound to the benefit of organization.

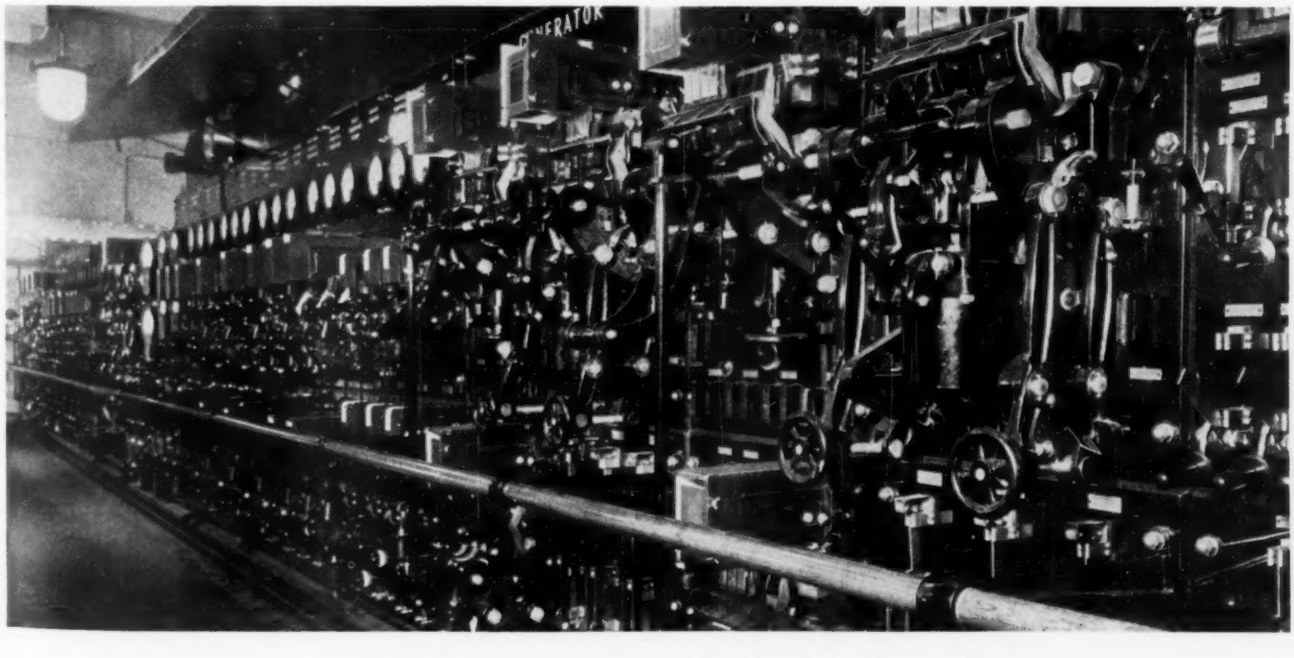
This is only one of the many comparisons or contrasts between British and American legislation which one is tempted to make. Miss Sells wisely refrains from such comparison, sticking to her job of description and analysis of the British experience. It may, however, be valuable to point out some of the more pronounced differences between the two approaches.

The first and most obvious contrast is to be found in the inclusiveness of the two schemes, historically considered. The FLSA applies, with some exceptions, to workers engaged in industries entering into interstate commerce, perhaps 11 million in all. The machinery of the trade boards was applied first to only four trades, and has been slowly extended to its present compass over a period of thirty years, now covering less than 3 million workers.

A second major contrast arises out of the absence of any legally prescribed national minimum wage in Great Britain. The FLSA, on the other hand, prescribes a minimum rate of 25 cents an hour, increasing ultimately to 40 cents unless particular industry boards set a rate, and the administrator approves, lower than 40 cents but not lower than 30. Such a minimum has on occasion been advocated in Britain, but never successfully. It should be noted, however, that there are relatively slight differences in the minima established for the various trades. The practical difference, then, would appear to lie rather in the process by which these minima were reached than in the actual results of the process.

A third, and to date perhaps the most important, difference lies in the relative significance of governmental as opposed to nongovernmental or quasi-governmental bodies. In this country, the industry boards have so far functioned within the framework of governmental machinery. In Britain, the trade boards, except for enforcement, *are* the essential machinery, and have tended to become more and more so with the passage of time. It is possible, of course, that the United States will move in the same direction; substantial changes along these lines could be made with little or no change in existing legislation.

As indicated in the foregoing, the reader will not find in Miss Sells' book direct or implied comparisons of the sort just mentioned. Nor will he find a vigorous championing or denunciation of the general principle of minimum-wage legislation. If, however, he is interested in discovering how the application of such legislation has worked in specific cases, he will be well repaid for his effort.



MAIN SWITCH BOARD OF CUNARD-WHITE STAR R.M.S. "MAURETANIA"

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

Day by Day

SO MUCH has taken place during the last month that the temptation to comment on it is almost irresistible. Even a bare recital of the events themselves would run to unwarranted length, and the significance of these events offers opportunities for disagreement. We are in the midst of developments whose outcome none can clearly foresee, and the tendency to rationalize in accordance with one's hopes adds dangerous pitfalls.

Most persons will agree, however, that the closing days of the 76th Congress found the New Deal facing more vigorous opposition than it has yet experienced, and with this trend many forces were in conflict and in unnatural alliance. Have we witnessed a repudiation of the lending-spending theory of recovery? Are we closer to the time-honored beliefs in the efficacy of thrift and hard work, of the profit system of American free enterprise as a realistic approach to the solutions of economic and social problems, of a return to traditional functions and relative obligations of private industry and government?

The storm that arose over changes in the administration of WPA, particularly over the prevailing-rate-of-wages issue, the sentiment in Congress which indicated the weakness of the proponents of old-age pension schemes of the Townsend variety, the setback experienced by the Department of Justice in its suit against the American Medical Association, the threat of the CIO to invade the construction industry and the proposed monopoly investigation of that industry, the return during July of million-share days on the stock exchange, the passage of the Hatch bill designed to reduce active participation of federal employees in national politics, the decision of the House to investigate the NLRB coupled with failure to amend the Wagner bill, and certain modifications in the patent procedure are some of the events whose future development engineers will follow with interest.

In Europe and the Far East the record of the last month has been even more confusing. Like our own Congress, Parliament and the Chamber of Deputies are in recess, leaving the Prime Minister and the Premier with heavy responsibilities and extraordinary powers for democratic governments. Army and naval maneuvers are in progress with millions of men under military discipline. Interest and tension in the Far East are high. Notice has been given of our intention to terminate the 1911 commercial treaty regulating trade and navigation with Japan. British technical journals are featuring articles on military preparedness and the production of implements of warfare. Engineers in Great Britain are being informed of opportunities to engage in national emergency service. August, the harbinger of wars, is in full season, with the immediate future in nerve-racking obscurity. The revolutionary economic, social, and political changes that forced the world's attention to their progress so dramatically twenty-five years ago are still in progress. The times are reminiscent of a world upheaval of a century and more ago, only today the area affected is broader because science and engineering have gradually annihilated isolation. For more than a century the more "advanced" nations have been in transition from an agrarian to an industrial economy. In the transition engineers have played important roles. Before it is completed they will be called to even greater tasks. With them as technicians no less than as citizens, lies the hope of peace and prosperity.

Army Air Corps

On August 2 the Army Air Corps celebrated the thirtieth anniversary of the purchase by the United States of its first airplane with simultaneous mass flights of more than 2000 Army planes throughout the nation and special exercises at Wright Field, Dayton, Ohio, near the home of the Wright brothers, whose 800-lb biplane with its 25-hp engine successfully met the specifications laid down by the Signal Corps in 1909. On a high-altitude nonstop flight from Burbank, Calif., to Floyd Bennett Field, the day before, a 22-ton "flying fortress," a Boeing 39 bomber, spanned the continent in 9 hours, 14 min, and 30 sec, flying at an average altitude of 20,000 ft and a speed of 250 mph. An altitude of 33,000 ft was reached at one point in the trip in an endeavor to fly over a storm area. Oxygen was used by the crew. The bomber proceeded to Wright Field to take part in the anniversary exercises. Among the guests at the exercises were Col. Frank P. Lahm, of New York, air officer of the Second Corps Area, and Brig. Gen. Frederick H. Humphreys, N.Y.N.G. (retired), who were instructed by the late Wilbur Wright to fly the first Army plane 30 years ago. Orville Wright, member A.S.M.E., was unable to attend the exercises, but telegraphed his best wishes.

Fifty-Year Job

On July 6 the Lidgerwood Manufacturing Company honored its vice-president and chief engineer, Jed S. Foster, member A.S.M.E., with a testimonial dinner commemorating his fifty years of service with the company. Fifty years with one company is a long period of service that speaks well for the quality of a man's work. Mr. Foster first became prominently associated with large engineering projects during the building of the Panama Canal. He has created machinery used in the development of water-power and irrigation systems. His latest achievement is the design and construction of the heavy-duty, overhead, high-speed cableway system for use in handling concrete for building the Shasta Dam, in California. He also designed the equipment used at Boulder Dam and the 150-ton permanent cableway at the dam site.

Mr. Foster, in a recent letter, wrote that half a century ago he aspired to junior membership in The American Society of Mechanical Engineers, and was admitted in 1891, "and naturally I have always had the greatest respect and confidence in the management and conduct of the Society. During that long period," he continued, "I have derived much benefit from the association with, and the facilities offered by, the A.S.M.E."

It is gratifying to know that the presentation of the gold medallion for "fifty years of meritorious service" and the "brace of pipes" marked only a pleasant interlude in Mr. Foster's career, for he will continue actively as vice-president and chief engineer of the company he has served so long.

Engineer Railroad Trustee

An editorial in the *New York Herald Tribune* for August 8 notes the activity of Walter Kidde, of New York, member A.S.M.E., as trustee of the New York, Susquehanna and Western Railroad, now in process of reorganization under the Federal bankruptcy act. According to the editorial, the road, under Mr. Kidde's management, has "initiated a novel experiment in railroading by incorporating buses that have taken a staggering amount of the New York passenger traffic from all the railroads in northern New Jersey during the last decade. Establishing Susquehanna Transfer, a new stop on the eastern edge of the Jersey meadows just two and one half miles to the Lincoln tunnel entrance by the Port Authority's new express highway, the railroad now offers commuters a fifteen-minute bus service through the tunnel direct to Times Square." Nor is this all, for "the line also proposes to build two streamlined, high-speed motor coaches that will be the first air-conditioned trains for local traffic in the metropolitan area. Operated in conjunction with the shuttle bus service," these will "bring Paterson within thirty-five minutes of Times Square instead of at least an hour, as at present."

Noting that Mr. Kidde "has a very successful record as an engineer," the editorial says that "his enterprise on behalf of the Susquehanna is turning out as favorable for the bondholders as for the traveling public. Despite decreased gross revenues and the inauguration of the road's first general repair program in five years, he reported last month that net earnings before bond interest for the first six months of 1939 were $170,480, compared with $78,216 in 1938."

Salute to Furer

An appalling mass of material flows over an editor's desk, and as years go by certain pieces take on the familiar characteristics of old friends with whom one wishes to pass a few moments to pick up a bit of information or a few words of comment. Such an old friend has been the *Weekly Bulletin* of the Engineering Association of Hawaii, a single-page mimeographed sheet signed Wm. C. Furer, Secretary.

With the issue of Vol. XII, No. 26, came also a mimeographed letter, dated June 26, 1939, and signed by Mr. Furer, in which suspension of the *Bulletin*, at least under his editorship, was announced. Mr. Furer has figured out that he has spent on the *Bulletin* 400 working days. "And that's a lot of time," he comments. "That's 15 months. You could make three leisurely trips around the world in 15 months." But there has been no time for these trips. Instead, as Mr. Furer explains, "these days have all been hard-working days. As mercilessly regular as time itself, these *Bulletin* days have cut deeply into domestic responsibilities, into social engagements, into professional commissions. The loss from the latter has at times been distressing. It's our duty now to make recovery. This voluntary undertaking accepted at first as a challenge to professional loyalty, soon grew into a hobby largely because of the many expressions of appreciation from members everywhere. Of late, however, the work is no longer dischargeable with undiluted enjoyment." And there is mention of "the weekly grind of manuscripting, typing, proofing, stencil-cutting, stencil-proofing, mimeographing, folding, and mailing."

Curiosity first attracted the editor to the mimeographed *Weekly Bulletin*. Mr. Furer put himself into his work. One got to know him, the regular Friday luncheon meeting at the Commercial Club, the speakers and what they said, Mr. Furer's comments on whatever happened to be uppermost in his mind. The *Bulletin* and the Association began to take on a personality—that of Mr. Furer, probably. On the weekly appearance of the *Bulletin*, other tasks were laid aside until it was read and passed on. Interesting comment and usually a chuckle were the rewards. And now Mr. Furer has laid down the pen, one hopes for that rest, and the return to friends, family, and business.

What we know about Mr. Furer and the Engineering Association of Hawaii has come only through the *Bulletin*. Many an organization is held together by the faithful service of a few men. What made him devote those 400 days to the *Bulletin* and the Association? Let him explain.

"The stimulus for these many weekly efforts," he says, "has come largely from the fine ethical code which pervades the engineering profession. The *Bulletin*, in turn, has tried to spread some of the engineer's ideals and his philosophy. It has reported the programs of the Engineering Association of Hawaii under eleven presidents; it has recorded the passing of more than a score of its members; it has published memorial resolutions, and it has recorded annual picnics. Its publishing has produced, we hope, a better acquaintance among the engineers of this Territory. It has produced a greater solidarity of the engineering fraternity of Hawaii than which there is no finer, nor keener, nor a more alert group at these Cross Roads."

[By later post: Stanford F. Brent takes up Mr. Furer's task.]

New I.C.C. Commissioner

William J. Patterson, director of the I.C.C. Bureau of Safety, was nominated by President Roosevelt on July 20 to be a member of the Interstate Commerce Commission, to fill a position for which the President had originally selected Thomas R. Amilie, of Wisconsin. Mr. Patterson is widely and favorably known in railroad circles and has been engaged in railroad affairs all his life. Born in Wisconsin, Commissioner Patterson studied air-brake and train operation with the International Correspondence Schools and started railroading as a call boy for the Wisconsin Central Railway. Later he became brakeman, fireman, switchman, and conductor on various roads. In 1914 he left his position as conductor on the Northern Pacific to become inspector of safety appliances for the I.C.C., where he was advanced to the office of director of the Bureau of Safety in 1934.

Babbitt Centenary

One hundred years ago, says a brief article in *The Dutch Boy Quarterly*, Isaac Babbitt, of Boston, Mass., invented a process of casting a relatively thin layer of soft metal on the inside surface of a strong, hard, bearing shell. In his patent specifications dated July 17, 1839, Babbitt stated, among other things: "The inner parts of the boxes are to be lined with any of the harder kinds of composition known under the names of britannia metal or pewter, of which block tin is the basis. An excellent compound for the purpose I have prepared by taking about 50 parts of tin, five of antimony and one of copper, but I do not intend to confine myself to this particular composition."

Babbitt's invention of a practical way to line bearings and his use of a tin-base alloy for lining purposes are landmarks in the bearing field. Since his time, the process of casting linings in bearing "shells" has been known universally as "babbit-

ting." Likewise, most of the white-metal alloys used for linings (although many differ widely from his suggested composition) have been known as "babbitts."

Isaac Babbitt was born in Taunton, Mass., in 1799. His early training was as a goldsmith and he is said to have been an accomplished artisan while still a very young man. In his twenty-fifth year, Babbitt directed his talents to the manufacture and sale of britannia ware. At that time, the market for britannia was monopolized by firms importing British-made products. Babbitt, who is credited with being the first manufacturer of britannia in this country, apparently turned out products equally as fine as those of his British competitors. He received awards from various expositions and his firm prospered.

Some time during the 1830's, Babbitt sold his britannia business and became associated with the South Boston Iron Co. While working for this concern, he developed the method of making journal boxes which he patented in 1839.

Facsimile Newspapers by Radio

THE NEW YORK PRESS

THE RADIO EDITION of the St. Louis *Post-Dispatch*, the world's first daily radio newspaper, has been broadcast daily since Dec. 7, 1938, over an ultra-high-frequency transmitter. The present experimental program, according to an article by Robert L. Coe in the August, 1939, issue of *The New York Press*, has two main objectives. The first is to determine whether equipment now available is suitable for establishment of a facsimile broadcast service. The second objective is to ascertain the public's reaction to facsimile broadcasting, in an attempt to determine the potential audience when, and if, suitable equipment is available.

FLAME-DESCALING

(An 18,000-lb steel casting for a hydraulic turbine is shown being flame-descaled in one fifth the time formerly required for chipping. Flame-descaling is a relatively new process for removing the scale from blooms, billets, slabs, forgings, and steel castings by means of specially designed oxyacetylene heating heads. The method is based on the principle that when high-temperature heat is applied to the scale or oxide skin on a piece of cold metal, the scale expands and breaks away from the base metal because of differential expansion between the scale and the steel.)

The present radio newspaper consists of nine pages, $8\frac{1}{2} \times 9\frac{1}{2}$ in. in size and four standard newspaper columns in width, which include general news, sports, pictures, an editorial page, and a reproduction of the Fitzpatrick cartoon appearing daily in *The Post-Dispatch*. Some criticism has been received about the seven-point type being used, but with the limited space available in the facsimile newspaper, small type such as this will have to be used.

As far as technical operation of the present facsimile system is concerned, relatively little trouble has been experienced. Receivers have operated entirely unattended week after week, with relatively few service calls except for renewing the paper supply. Within the thirty- to fifty-mile range of the station, there was not a single location where satisfactory facsimile reception could not be secured. Of course, another advantage of the ultra-high-frequency band is that static is practically unknown. Even a severe electrical storm in the immediate vicinity of the receiver causes only a few very fine black marks on the copy, which do not seriously mar reproduction of the picture, nor interfere with the legibility of the printed page.

1938 Machinery Accidents

NATIONAL SAFETY COUNCIL

ACCIDENTS do not happen but are caused by someone's carelessness, inattention to duty, or lack of thoughtfulness. One thoughtless moment may mean years of suffering for a human being and, many times, financial loss to his company because of damaged machines and interruption of production. Engineers in the machinery industry are doing a fine job in the training of employees in proper safety measures and in the elimination of accident hazards, as is shown in the 1938 figures compiled for the industry by the National Safety Council, Chicago, Ill.

According to this annual statistical report, manufacturers of machinery averaged 8.29 reportable injuries per 1,000,000 man-hours of exposure (injury frequency rate) and 0.70 days lost per 1000 man-hours of exposure as a result of reportable injuries (injury severity rate). These figures are based on reports from 291 plants whose employees worked 512,527,000 man-hours during the year. The frequency rate is 32 per cent below the average for all industries and the severity rate is 54 per cent below the general average. The machinery industry stood well toward the top among 30 major industries, ranking tenth in frequency and eighth in severity.

Machines were the outstanding agency of injury in the industry, being involved in 60 per cent of all serious cases. Punch presses alone figured in one third of the machinery accidents. Of other types of machinery, milling machines, lathes, drill presses, grinding wheels, and power-driven saws were reported most frequently. Elevators and hoisting apparatus were second in importance, and were followed by hand tools.

The principal unsafe act involved in 239 fatalities and permanent partial disabilities occurring during the last two years was the unsafe use of tools, machinery, and other equipment, including the use of defective tools and equipment, unnecessary exposure to danger, such as handling objects by gripping them

insecurely, taking the wrong kind of hold, and lifting improperly, and placing the body or its members in hazardous positions, such as standing under suspended loads, putting body members into openings, or entering areas that are unsafe due to electrical or gaseous hazards.

The principal mechanical causes involved in 470 serious injuries were unsafe processes, working methods, planning, and poor housekeeping. Next in importance was improper guarding. Improper attitudes, such as disobedience of instructions, recklessness, abstraction, and haste, were the most important personal causes in these cases.

Aviation in the United States

CIVIL AERONAUTICS AUTHORITY

ACCORDING to an announcement of the Civil Aeronautics Authority, Washington, D. C., there were 26,144 civil pilots and 11,160 aircraft holding active certificates on July 1, 1939. This was an increase of more than 6000 pilots and of more than 1400 aircraft since July 1, 1938, when the totals were 20,076 pilots and 9732 aircraft. In the private classification alone, during the last six months, there has been an increase of 971 pilots of which number 228 were college students who received their certificates after training under the experimental phase of the C.A.A. vocational flight-training program inaugurated in 13 schools during the second semester of the 1938-1939 school year.

The United States had 2326 airports and landing fields on July 1, 1939, of which 730 were fully or partially lighted for night use. The total included 760 municipal and 454 commercial airports, 262 C.A.A. intermediate landing fields, 595 auxiliary fields, 27 naval air stations, 57 military airdromes, and 170 miscellaneous government, private, and state airports and landing fields.

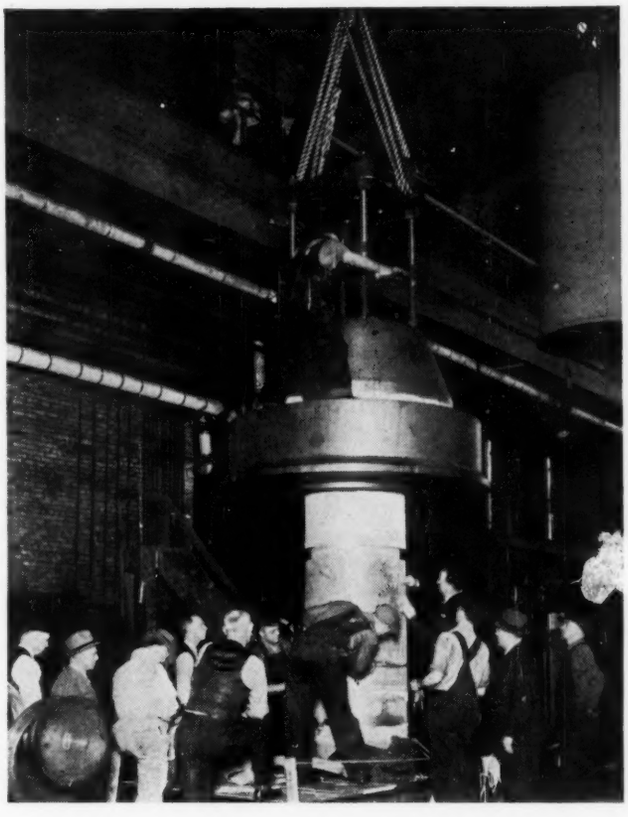
Oil Treatment of Coal

BITUMINOUS COAL RESEARCH, INC.

THE APPLICATION of oil to coal for the reduction of dust has been studied and the results are summarized in a 36 page report, "The Treatment of Coal With Oil and Other Petroleum Products," by J. M. Pilcher and Ralph A. Sherman, member A.S.M.E., fuel-research engineers of Battelle Memorial Institute, Columbus, Ohio. Distributed without charge by Bituminous Coal Research, Inc., the publication is based on the results of a two and one-half year program of research at Battelle. A progress report giving the principal results of the work of the first year was presented by the authors before The American Society of Mechanical Engineers in December, 1937, and published in A.S.M.E. Transactions, February, 1938.

Petroleum oils and blends of oil with wax and with asphalt are eminently suitable materials for the treatment of coal to allay dust, say the authors, because the materials stick the fine pieces together so that they cannot fly about not only when first applied but over a year or more, the oil retaining its effectiveness in outdoor storage about as well as in indoor storage. The most important characteristics of oil that determine their suitability for the treatment of coal are: (*a*) viscosity, (*b*) flash point, (*c*) pour point, and (*d*) odor. Considered generally for all coals, the viscosity of oil at 100 F is the most important characteristic that determines the effectiveness and permanence of dustless treatment.

The importance of viscosity varies with the rank of the coal.



DRY ICE HELPS FIT THRUST COLLAR ON GENERATOR SHAFT

(The picture shows a 93-in-diam thrust collar being lowered onto the upper part of the generator shaft of one of the three 30,000-kva, 13,800-v generators under construction by Allis-Chalmers for the Chickamauga Dam of T.V.A. In order to shrink the 34-in-diam generator shaft, its hollow bore was packed with dry ice and the outside covered with insulating felt to avoid excessive collection of moisture during the shrinking process. The men are shown removing the insulation from several spots to permit checking of diameters by means of a large caliper just before the thrust collar was finally lowered. The outside shaft temperature reading at this time was approximately 23 F. The heavy weight, shown at the right and held in reserve, was not needed in carrying out this press-fit operation.)

With high-rank bituminous coals of the Pocahontas No. 3 or semibituminous type, oils having viscosities between 100 and 600 sec, Saybolt Universal, are equally effective and permanent. With low-rank coals, such as Illinois No. 6, the higher-viscosity oils and blends of oil and petrolatum or asphalt are much more effective than oils of lower viscosity. With intermediate-rank coals, such as Pittsburgh and Island Creek seams, the increased effectiveness and permanence of higher-viscosity materials are less pronounced than with low-rank coals. The lack of permanence of oils of low viscosity on low-rank oils is attributed to absorption of the oil in minute cracks in the coal. The inherent moisture content of a coal is some indication of the extent to which absorption of oil will occur.

The data in the report showing how many quarts of oil must be applied per ton of different sizes of various coals are based on results obtained both in the laboratory and in the field. Samples of coal were treated in an experimental treating machine which simulated equipment used at coal tipples. Oil was atomized, not sprayed, under controlled conditions of pressure and temperature to form a fog that settled on the coal as it dropped from a conveying belt. After treatment the dust produced in handling the coal was determined after varying periods of storage both indoors and out. It was found that the quantity

of oil required to treat successfully various sizes of coal from the same seam is approximately proportional to the relative surface areas exposed for coverage with oil, and therefore, inversely proportional to the square of the mean size.

The pressure under which the oil is atomized depends upon its temperature. At atmospheric temperature the pressure should be from 300 to 700 psi; if heated to 180–200 F, a pressure of 100–150 psi will suffice. The advantages of the "cold" system of application at atmospheric temperatures and high pressures are that heating equipment and thermostats are not required. However, the system is limited to the use of oil that will flow and atomize under existing temperature conditions. The maximum satisfactory viscosity is 200 sec; frequently in winter, difficulty is encountered with oils of viscosities greater than 100 sec. Higher pressures require heavier and more costly piping, valves, and fittings, and increase difficulty of controlling fog. Furthermore, changes in temperature create difficulty in maintaining a uniform rate of oil flow.

The advantage of the "hot" system is that the temperature of the oil is under thermostatic control and therefore always the same regardless of the atmospheric temperature. As a result the oil is applied at a more nearly constant rate and uniform manner. The "hot" system is more flexible in that oils of high as well as low viscosity may be used, depending upon the requirements of the coal and the relative price of the oil. The lower pressure makes it easier to control the escape of oil fog and permits it to settle on the coal.

Other facts brought out by the authors are that the treatment of coal with oil has no appreciable effect on the performance of coals in residential underfeed stokers, that oil reduces the difficulty with freezing, that it reduces the retention of surface moisture on coal, and that it does not increase but may decrease the tendency of stored coal toward spontaneous heating.

Combustion in Small Stokers

A.S.M.E.-A.I.M.E. FUELS MEETING

AT A joint meeting of the A.S.M.E. Fuels Division and the A.I.M.E. Coal Division, Chicago, Ill., Oct. 13–15, 1938, C. A. Barnes, assistant fuel engineer, Battelle Memorial Institute, Columbus, Ohio, presented a paper "Some Aspects of Combustion in Small Underfeed Stokers," which included some of the results of an investigation, reported in full in Technical Report No. 4, "Fundamentals of Combustion in Small Underfeed Stokers," of Bituminous Coal Research, Inc., Washington, D. C. An abstract of the paper follows:

Despite the rapid acceptance of the small underfeed stoker for residential heating and its successful adaptation to a wide variety of coals, difficulties are encountered with certain types of coals. The solution of these difficulties has been hampered because only the over-all results of the process of combustion have been known and information on the details of the process of combustion within the fuel bed has been lacking. The purpose of this investigation which was sponsored jointly by Bituminous Coal Research, Inc., and Battelle Memorial Institute was to supply this lack.

The studies were conducted on a typical pot-type small underfeed stoker which was mounted on an elevated framework to permit the insertion of specially designed probes into the fuel bed from below. Through these probes, temperatures were measured and gas samples were withdrawn for analysis. In this way, the rate of heating of the fuel and the progress of combustion in the bed was followed. Temperatures and gas samples were also taken above the surface of the fuel beds. The rate of burning was known by the loss of weight of the furnace assembly which was mounted on scales. The rate of air supply was measured by means of the pressure drop across a thin-plate orifice. The rate of feeding of fuel was varied by means of interchangeable pulleys on the motor and speed-reduction unit.

From the series of burning tests under conditions of continuous and intermittent operation comparable to normal operating conditions using high-temperature coke and coals from the Millers Creek and Pittsburgh seams, the following conclusions are drawn:

1 The combustion of coal and coke in a small underfeed stoker is not a stable process even under conditions of continuous operation. The burning rates for different portions of the fuel bed as evidenced by fluctuations in temperatures and gas compositions in the fuel bed are continuously oscillating about some equilibrium value.

2 Combustion in the fuel beds of both coal and coke fires is not symmetrical with respect to the center of the retort. At all normal rates of air supply, an excess of air passes through the front of the retort adjacent to the hopper, whereas a deficiency exists at the center and usually at the rear. The gases arising from the center and the rear of the fuel bed contain combustible that must be burned in the combustion space. More overfire combustion space is, therefore, required than if uniform mixing occurred within the fuel bed. An increase in the air rate increases the overfire air without necessarily improving the combustion in the fuel bed itself.

3 The maximum temperatures measured in fuel beds of coke were found in the center of the retort and ranged from 3000 to 3100 F. Maximum temperatures for Millers Creek and Pittsburgh-seam coals normally ranged from 2400 to 2800 F. The zone of high burning rate for Millers Creek and Pittsburgh-seam coals normally ranged from 2400 to 2800 F. The zone of high burning rate for Millers Creek coal extended as an annular ring around a cone of comparatively cool fuel at the center of the retort. That of Pittsburgh coal was variously at the center or near the edge of the bed, depending upon the nature of the channeling through the coke structure at the time of measurement.

4 The thickness of the combustion zone ranged from $3\frac{1}{2}$ to 5 inches for coke, 3 to 6 inches for Millers Creek coal, and 6 to 8 inches for Pittsburgh coal. The ignition level for Millers Creek coal varied from 2 to 4 inches below the top of the retort at the edges to well above the top of the retort at the center. The ignition level for coke was less curved and was generally near the top of the retort. That for Pittsburgh coal varied from the top of the retort to well above the top, depending upon the formation of the coke in the bed. Increasing the percentage of excess air decreased the thickness of the combustion zone, and for coke raised the ignition level with respect to the top of the retort. The trend was less definite with coal.

5 Fuel beds of different-size lots of Pittsburgh-seam coal were closely the same, indicating that the removal of the finer sizes from caking coals does not affect materially their burning characteristics during periods of continuous operation.

6 The rate of heating of the surface of fuel feeding to the ignition level during periods of continuous operation was computed as 250 F per minute. Off-period rates were 100 and 20 F per minute at distances below the ignition level of $\frac{1}{2}$ inch and 1 inch, respectively. Any tendency of the more rapid rate of heating to give more and stronger coke during periods of continuous operation will be largely offset by higher burning rates and by the action of the feeding fuel in breaking up the coke formed. Intermittent operation favors the formation of coke trees.

7 Underfeed stokers do not burn coke and coal strictly on

the underfeed principle but on a combination of underfeed, cross-feed, and overfeed burning. Actually, a very small percentage may be underfeed burning. The extent to which the different types of burning occur for a given fuel has not been determined but it is a function of the stoker design and of the feed and air rates.

8 Coke may burn in an underfeed stoker to give a uniformly incandescent-topped fuel bed characterized by an area or areas of unignited fuel at the top of the bed near its center, designated respectively as "red top" and "black center" burning. Black center occurs at high air rates and is caused by ignition level breaking through the surface of the fuel bed. As the ignition level may vary anywhere from the tuyères to the top of the fuel bed, however, black center might be more appropriately regarded as a degree of a certain-type burning rather than as a separate and distinct type. Black center burning is accompanied by decreased stack temperatures, decreased burning rates, and lowered combustion efficiency.

9 Due to the variable extent of the different types of burning that occur in the retort of an underfeed stoker, the over-all operation of the stoker cannot be predicted from findings in an ideal fuel bed. The range of operation as calculated on the principle of ideal underfeed burning was greatly exceeded for fuel beds of coke in the underfeed stoker.

Austempering Steel

ARTHUR D. LITTLE, INC., INDUSTRIAL BULLETIN

METALLURGISTS have recently developed a way of cooling steel which makes it not only hard but also ductile. Austempering, as the method is called, enables one to bend a shovel double and have it spring back into shape, or to bend a hard steel rod far more sharply without breaking it than an ordinary quenched and tempered rod of the same hardness and composition. Yet the remarkable results of austempering are not products of an intricate machine or an abstruse chemical reaction, but of a simple understanding of the way iron and carbon act together upon cooling.

The object of rapidly quenching hot-worked steel into water or oil is to force transformation of austenite, the crystal structure characteristic of steel heated above its critical temperature, to the hard and brittle structure of martensite, formed at low temperatures. Unless the cooling is rapid, transformation will set in at around 1000 F and yield a very soft though ductile product. The hard and brittle martensite formed by the quenching must ordinarily be tempered by reheating to around 600 F. Tempering improves ductility at the expense of hardness and gives a better combination of the two properties. In the opinion of many metallurgists, however, the stress of quenching results in submicroscopic cracks, incapable of removal by tempering, which thereby permanently rob the steel of a portion of its ductility.

The austempering process is a means of retaining maximum ductility consistent with hardness in a single treatment free from the stresses accompanying ordinary quenching. The original hot steel is not quenched at low temperatures and subsequently reheated, but is quenched at a temperature in the vicinity of the customary tempering zone (about 600 F) and is held there for a considerable time—a matter of minutes or sometimes even hours, rather than of seconds—until the change is complete. The optimum holding period depends on the composition of the steel, and must be determined individually for steels of varying composition. The steel goes directly from austenite to a superior and more uniform final structure without the intervention of the hard and brittle highly stressed state, and the product, consequently, has better and more dependable ductility for a given hardness.

Austempering somewhat resembles the familiar art of hot quenching, but the austemperer, understanding the importance of the time factor, holds the steel at the hot-quenching temperature long enough for the slow transformation of the austenite (in this temperature zone) to be completed. Metallurgists have clarified the theory of the austenite transformation, and have been able to obtain data on transformation time and product characteristics at different temperatures. Knowing what will happen at each temperature level, it has been possible for them to pick the level which will give just the product desired.

An important aspect of this research is its aid to an understanding of one important function of alloying elements in steel, i.e., retarding the onset and completion of the austenite transformation. This delay permits the alloy steels to be heat-treated in larger sections, whereas comparable sections of ordinary steel cannot, under any circumstances, be quenched fast enough to prevent transformation of the interior to the soft products formed at high temperatures. If the steelmaker knows how an alloy works, he may, for some purposes, be able to decrease the amount required or even do entirely without it, for a given quality of steel, or maintaining the alloy, to improve the quality. While sufficiently rapid cooling of thick sections of unalloyed steel is still impossible, the austempered product in sections less than $^3/_8$ in. thick is reported to duplicate the principal advantages of a number of alloy steels, and accordingly may supplement, modify the composition of, or displace some low-alloy steels.

Railway-Highway Competition

METROPOLITAN SECTION, THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

GREAT BRITAIN, like the United States, is confronted with the problem of controlling the competition between railway and highway transportation for the mutual benefit of the two classes of operators and the shippers. In a paper presented before the Metropolitan Section, The American Society of Mechanical Engineers, in New York, May 4, 1939, W. L. Waters, member A.S.M.E., outlined some of the important facts he was able to develop from his recent study of railway and highway competition in Great Britain. Since the British problems are very similar to those found in this country, a summary of Mr. Waters' findings is herewith presented.

The total annual income from motor-vehicle taxation in Great Britain, at present, is about one third more than the total cost of the construction and maintenance of the highways and city streets. Fees from licenses and gasoline taxes are no longer earmarked for highway purposes, but are considered to be a part of the national revenues.

Taking advantage of the public sentiment after the coal and general strikes in 1926, and because of the seriousness of highway competition by busses and trucks, the railways, in 1928, applied for and obtained comprehensive powers to operate on the highways and to invest in such undertakings. So they now have a financial interest in about one third of the highway busses and own or control about one tenth of the highway trucks. As a result of the activities of the railways, highway bus service is now a well-organized industry, while trucking is still in a chaotic condition due to competition and cut-rate truckers.

Highway busses are licensed as to routes and licenses are only issued when a need for the service can be shown. Public-haulage trucks (called common carriers here) are licensed as to the district to be served, with licenses being issued only when adequate transport facilities are not available in the district.

Licenses for private trucks are granted as a matter of right. But public sentiment is slowly developing to have private trucking regulated. This is based on the idea that if public haulage is so restricted and regulated that private trucks take all the traffic, the public will demand that private haulage be also strictly regulated.

Vehicles, drivers, hours of work, speed limits, and conditions of operation for all vehicles are regulated by laws which are very difficult to enforce. Wages of public-haulage truck labor are now regulated by a central board, and there is indirect control over the wages of private truck labor.

To meet highway competition, the railways are permitted by law to make special rates as low as 40 per cent below standard rates without the approval of the rates tribunal, and special agreed charges (contract rates), subject to the approval of the tribunal, to handle any large shipper's freight. Such agreed charges seem to be anything the railway decides to charge.

Since the war, heavy commodity exports have decreased, industries have been rationalized or relocated, new industries have been developed, population has shifted to the cities, and highway trucking has developed, the character of freight traffic has changed much. Private passenger automobiles, and to a lesser extent highway busses, have taken passenger traffic from the railways, so that it has been necessary to reduce fares, offer special excursion rates, develop luxury services. The speed of both freight and passenger service and the facilities offered have also been much improved. The result of all these changes has been that railway net revenues have been reduced about one third.

As a remedy for the conditions, labor interests advocate that all transport, both railway and highway, be placed under a national transport board. If war develops this will probably result; but otherwise neither the public nor the railway companies are ready for this step.

In November, 1938, the railways officially asked to be released from the existing control of rates and freight classification regulations by the rates tribunal, so that they would have the same freedom as other forms of transport. This official request is possibly somewhat of a camouflage, since the railways are really more interested in having trucking rates controlled. The request is being considered by a transport advisory council appointed by the Ministry of Transport to represent all interests, and negotiations between the railways, the highway interests, and the shippers are proceeding satisfactorily. So it seems likely that the British railways will, in the near future, obtain some relief from the pressure of unregulated highway competition. The question of stabilizing the trucking industry will also be affected by the policy followed in the taxation of highway vehicles, the relative level of rail and trucking wages, the development of freight tonnage to be handled, and the development of highways and toll roads.

Snow Cruiser

RESEARCH FOUNDATION OF ARMOUR INSTITUTE OF TECHNOLOGY

THE Research Foundation of Armour Institute of Technology has made public a brief description of the "snow cruiser," designed under the direction of Dr. Thomas C. Poulter, as a means of transportation for the projected antarctic expedition, authorized by the President of the United States and the Director of Territory and Island Possessions. It is expected that the expedition will get under way sometime in October.

The accompanying drawing, Fig. 1, of the 55-foot vehicle with its five-passenger pick-a-back airplane, for aerial explorations of a region 600 miles wide over a given route, shows the exterior of the arrangement and the 10-foot-diameter electric-motor-driven wheels. Two Diesel-electric power plants will generate the electricity needed. The snow cruiser, which combines a well-equipped laboratory with quarters for the crew for a period of one year without contact with the outside world, will have cruising radius of 5000 miles, a speed from 10 to 30 mph depending on grade, surface conditions, and weather, is 15 ft high, and will be able to span crevasses 15 ft wide.

As second in command and senior scientist of the Byrd Antarctic Expedition II, Dr. Poulter made a study of exploration methods and conditions enabling him to design the snow cruiser for best use. The following sixteen points are stated by Dr. Poulter as being requirements for an exploration unit:

1 The ideal antarctic exploration unit must have a cruising range of from 4000 to 6000 miles.

2 It must be capable of negotiating open crevasses of as much as 15 ft wide.

3 It must be capable of approaching within 100 to 200 miles of any point on the antarctic continent or barrier ice, and have auxiliary means of covering that distance.

4 It should have some means of attaining a high altitude for observing long distances and making aerial photographs.

5 It should have a cruising speed of not less than 5, and preferably 10 mph.

6 It should be possible to stop at any location for as long as desired with no consumption of supplies for the unit during its stay there, and only the normal consumption of food for men and fuel for their comfort.

7 It should carry a crew of not less than three nor more than six men—preferably about four.

8 No large or elaborate base camp should be required.

9 It should be possible from the unit to determine the position of any mountain peak or prominence visible from the unit within a half mile.

10 It should not require any special precautions in case of

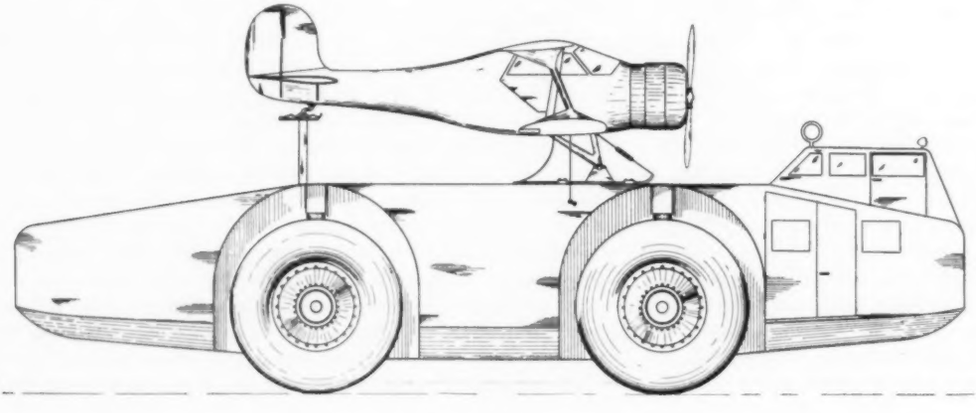


FIG. 1 FIFTY-FIVE - FOOT SNOW CRUISER DESIGNED BY RESEARCH FOUNDATION OF ARMOUR INSTITUTE OF TECHNOLOGY WITH TEN-FOOT RUBBER-TIRED WHEELS AND FIVE-PASSENGER PICK-A-BACK AIRPLANE, TO BE USED IN ANTARCTIC EXPLORATIONS

a blizzard; all that should be necessary should be to head the unit into the direction of the prevailing wind and stop for any length of time.

11 It should be possible to travel with the unit throughout any month of the year except during blizzards.

12 It should be so equipped and manned that it would be possible to travel 24 hours per day and permit sufficient time and facilities for the men to have regular meals and the required amount of sleep.

13 It should carry all necessary provisions for the crew for a period of at least one year.

14 It should provide emergency means for the crew to reach some point on the coast where seal meat is available, or where a ship can pick them up or a camp. It should be possible to accomplish this within a period of hours, or at the most, a few days under favorable weather conditions.

15 It should have adequate radio equipment for reliable communications with the States.

16 It should carry complete facilities and personnel for a very comprehensive scientific program.

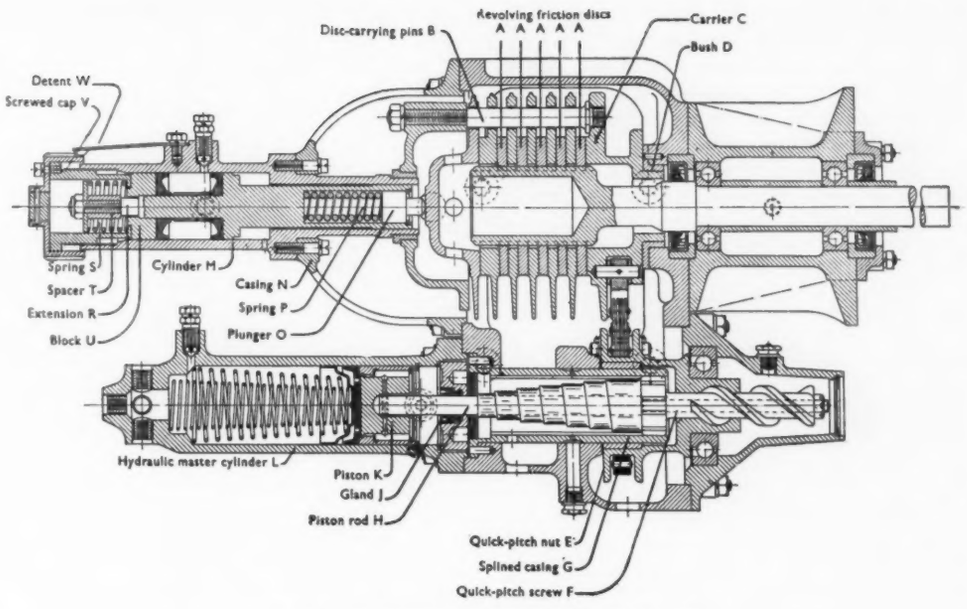


FIG. 2 REGENERATIVE BRAKING APPARATUS

Regenerative Braking

MECHANICAL WORLD (GREAT BRITAIN)

BRAKING is applied not only to road vehicles but to industrial machines, some of which may run continuously or may require stopping from time to time, and all of which require stopping in the event of an accident or an impending accident. Improvements designed to relieve the machine operator of the effort required to apply powerful brakes have taken two forms. The power-operated brake is one type. The other type is the regenerative brake in which power absorbed from the moving parts is applied in such a way as to assist the stopping action. An example of the latter type is described in an article appearing in *Mechanical World* (Great Britain) for June 2, 1939.

Briefly, the apparatus consists of a clutch which is engaged to transmit power from a rotating part of the machinery to a hydraulic cylinder, the generation of pressure in the latter being controlled, also hydraulically, by the operator of the machine, and regulated in its growth by the apparatus itself. For some of the industrial applications the control is electric instead of hydraulic. The clutch portion, Fig. 2, consists of a number of small friction disks *A* splined to the booster shaft; these alternate with a number of cast-iron annular members extended in diameter to form cooling fins. The annular cast-iron members are carried on a number of pins *B*, extended from a carrier *C*, supported on the bakelite-graphite self-lubricating bush *D*.

The periphery of this carrier has a groove formed in it around which a stout chain can wrap in either direction. The other end of the chain is wrapped round a quick-pitch nut *E* which has formed on the inside of it a quick-pitch thread. In the "off" position the chain is wrapped entirely around this member and the length is adjusted so that it will bring the carrier *C* to such a position that the chain is right off the latter, i.e., its point of anchorage is on a line with the line joining the center of the two chain carriers, *C* and *E*. Thus, whichever way the carrier *C* turns, rotation of the quick-pitch nut *E* will always be in the same direction.

Working in *E* is a multistart quick-pitch screw *F*, which is anchored against rotation by splines formed in the interior of the casing *G*. This screw butts up against a short piston rod *H* which passes through a hydraulic packed gland *J* and is arranged to bear against a hydraulic piston *K* in a hydraulic master cylinder *L*. The remote end of this cylinder is in direct communication with the control, while the near side of the cylinder (which also contains fluid) communicates with a small cylinder directly actuated by the control and also with a cylinder *M* on the remote end of the clutch casing *N*. The piston of this latter cylinder, when extended, puts pressure on the clutch members through the spring *P* and the plunger *O*, the resultant thrust of the clutch on the body of the device being taken by a shoulder on the bakelite-graphite bush *D*.

On pressure being applied to the brake control, pressure is set up in the control cylinder and is communicated to the front end of the master cylinder *L* and also to the cylinder *M*. The effect of this is to energize the clutch, causing a torque to be produced and communicated via the chain to the quick-pitch nut *E*. Thus the quick-pitch threaded spindle puts pressure on the master-cylinder piston *K* and applies the brake. But the moment the piston *K* moves it tends to reduce the pressure on the front side of itself, i.e., in the servo line, and also to reduce the pressure in the clutch-energizing cylinder *M* and thus de-energize the clutch. Between these varying factors, therefore, a balance is established which is exactly proportional to the amount of pressure applied to the brake control and also to the piston of the clutch cylinder *M*.

From the illustration it will be noted that the end of the clutch cylinder *M* is provided with a screwed cap *V*, whose remote end secures the end of the retracting spring *S*. By rotating this cap the whole of the piston assembly is moved forward or backward without interfering with the action of spring *P* and its stops, and thus allows for adjusting the clutch and for

taking up any wear in the clutch plates which may occur. The screw cap V is held by a spring detent W which fits into slots cut in the cap. This permits the turning of the cap with the fingers, thus making possible the adjustment of the booster without using any tools whatsoever.

This type of regenerative brake has been applied to such industrial machinery as rolling mills, calender mills, and printing presses, as well as its original purpose of braking the heavier types of motor vehicles on which it has proved very effective.

Marine Steam-Power Plants

THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS

THAT THE INCENTIVES for the use of high pressures and high temperatures in marine steam-power plants are reduced fuel consumption and reduced weight of the propelling machinery, is the contention of C. Richard Soderberg, member A.S.M.E., in a paper presented at the spring meeting of The Society of Naval Architects and Marine Engineers, held at M.I.T., Cambridge, Mass., May 23, 1939. He goes on to say that these considerations are interrelated in the sense that the reduction in weight is principally a result of the reduced volume as well as mass of the steam flow.

When a certain limit in maximum steam temperature has been established, it is possible to construct a thermal cycle of optimum efficiency. This cycle represents a compromise of technical and economical considerations. The means available to marine engineers for enhancing this optimum efficiency in steam cycles are reheating and regenerative-feed heating. Assuming a present practical limit in maximum temperature of 900 or 950 F, it is questionable whether reheating will prove an economical possibility. This leaves the regenerative-feed-heating cycle as the most promising approach to higher operating economy. The number of extraction points becomes an economic problem, the solution of which will depend on the conditions of each individual application.

The choice of inlet pressure depends upon the permissible exhaust moisture, the steam flow through its influence upon the efficiency of the first stages, and a variety of economical considerations. Under present premises, the very high pressures can probably be justified only for the largest capacities.

Table 1 gives a comparison of ideal efficiencies of a series of plant conditions. These efficiencies are based on zero losses throughout the cycle. The extraction points for feed heating have been placed so as to divide the enthalpy drop in equal parts. On this basis there is a possible fuel saving of about 25 per cent between 400 psi, 700 F, and 2400 psi, 950 F. The actual saving will probably be somewhat less, but the figures give a good indication of the incentive for advancing the steam conditions.

The applicability of any one of these plants to a given case depends principally upon the moisture content in the exhaust. With present means of erosion protection and moisture removal of the last-row blades, this moisture content probably can be raised beyond the limit of 12 per cent, which has become conventional on land installations. Due to the lower turbine efficiencies, and the poorer vacua, it is probable that marine installations on this basis may justify relatively higher operating pressures than land installations.

The information of the last three lines of Table 1 has been prepared to illustrate this condition. The moisture content is a practically linear function of the internal efficiency of the turbine, so that other values may be obtained by straight-line interpolation.

The fuel rates that can be obtained for any one of these plants depend on the details of the plant and the requirements of auxiliary power. With a fuel of 18,500 Btu per lb and a drive of the approximate size of 10,000 hp, it would not be unreasonable to predict a fuel rate of 0.60 lb per hp-hr for plant A, and 0.47 lb per hp-hr for plant F, indicating a possible saving of plant F over plant A of 21.7 per cent.

TABLE 1 IDEAL EFFICIENCIES—28½ INCHES VACUUM

Plant	*A*	*B*	*C*	*D*	*E*	*F*
Pressure, psi, gage	400	600	800	1200	1800	2400
Temperature, F	700	750	850	900	950	950
Carnot efficiency, $1-T_2/T_1$	0.525	0.544	0.579	0.594	0.609	0.609
Ideal efficiency, straight condensing	0.355	0.375	0.394	0.412	0.430	0.438
Feed heating						
In stages	2	2	3	3	4	5
To temperature, F	320	349	406	441	507	570
Ideal efficiency	0.383	0.409	0.428	0.461	0.500	0.510
Saving, per cent	0	6.4	10.5	17.0	23.3	25.0
Exhaust moisture, per cent						
Turbine, efficiency, 70 per cent	6.0	6.6	4.9	5.6	6.6	8.9
Turbine efficiency, 75 per cent	8.2	9.0	7.4	8.3	9.5	11.8
Turbine efficiency, 80 per cent	10.4	11.3	10.1	11.1	12.4	14.6

Professor Soderberg then traces the probable direction of developments and expands on the mechanical properties of metals at high temperatures. He states, the problem of creep has been singled out as the most important of these nonelastic properties and a review of its major aspects is certainly justified in the present condition. For most of the steels of interest in the present connection this creep rate depends approximately upon stress and temperature in such a manner that an arithmetical increment in stress or temperature brings about a geometrical increment in creep rate. This law makes it possible to determine the increments in stress and temperatures which are required to double the creep rate. Also discussed are related problems in failure, wear and seizure, embrittlement, fatigue, and corrosion.

The design of geared turbines has always been made more difficult by the necessity for astern operation and maneuvering. The advance of the steam temperature may be expected to accentuate this situation still further. The most serious aspect of prolonged astern operation, however, is the danger of overheating the proportion of the turbine which carries the ahead blading. The windage loss for an individual blade row depends upon the following variables:

1 It varies directly with the density (absolute pressure) of the steam.

2 It varies directly with the third power of the peripheral speed of the blading.

3 It varies directly with the annulus of the blading.

4 Idling in the astern direction produces windage losses which are about ten times those for idling in the ahead direction.

The advance toward higher operating conditions serves indirectly to increase these losses through the greater possibilities for poorer vacuum during astern operation, and through the likelihood of using higher operating speeds. The losses to be dissipated are often quite large.

The fire hazard incidental to failure of lubricating-oil pipes is very real at all operating temperatures above 700 F, and there is no fundamental difference created in this respect by further advances of steam temperatures. The ease with which oil will ignite upon contact with hot steam parts is much increased by temperature and the prevention of all possibilities for such fires must be regarded as a very important part of the development toward higher steam temperatures in marine power plants.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the committee and passed upon at a regular meeting of the Committee.

This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and also published in MECHANICAL ENGINEERING.

Following is a record of the interpretations of this Committee formulated at the meeting of June 23, 1939, which were subsequently approved by the Council of The American Society of Mechanical Engineers.

CASE NO. 878

(Interpretation of Par. U-59p)

Inquiry: According to Par. U-59p (2), a 3-in. pipe size coupling may be welded into the shell of any U-69 vessel without stress relieving, but under U-59p (1) stress relieving is required when a plain-end 3-in. pipe is welded to a shell less than 35-in. in diameter. Will it not be permissible to weld a plain-end pipe without stress relieving, up to and including 3-in. standard pipe size and without regard to the diameter of the vessel?

Reply: It is the opinion of the Committee that there is an overlap between sections (1) and (2) of Par. U-59p, and that a 3-in. plain-end pipe or tube welded under the provisions of Par. U-59p (2) will also comply with the intent of the Code provided the reinforcement requirements of Par. U-59 are complied with.

CASE NO. 879

Special Ruling

Inquiry: Is it permissible under the Code for Unfired Pressure Vessels to single fusion butt-weld circumferential joints in seamless Monel metal tubing of the chemical and physical properties, given below, or copper-nickel tubing (Specification S-47, 80–20 type A or 70–30), having a maximum outside diameter of $1\frac{1}{4}$ in., and a maximum wall thickness of 0.18 in., when the joints are to be oxyacetylene-welded with complete fusion to a depth not less than the metal thickness?

MONEL METAL

Nickel, per cent	63–70
Iron, per cent, max	2.50
Aluminum, per cent, max	0.50
Manganese, per cent, max	2.00
Carbon, per cent, max	0.30
Silicon, per cent, max	0.50
Sulphur, per cent, max	0.02
Copper	remainder
Tensile strength, lb per sq in., min	70,000
Yield point, lb per sq in., min	30,000
Elongation in 2 in., per cent, min.	20

Both the process and welding operators would be qualified under the latest revision of Par. P-112, with the following exceptions:

(1) The qualification test may be made on a flat plate $\frac{3}{8}$ in. in thickness;

(2) The tubes will be welded only in the horizontal position and revolved during the welding process so that the weld metal will be deposited vertically downward;

(3) All such welded joints are hydrostatically tested to twice the working pressure, or a minimum test of 1000 lb per sq in.;

(4) Stress relieving is not required and the excess weld metal or reinforcement shall not be removed.

Reply: It is the opinion of the Committee that the fusion welding of tubing in accordance with the limitations stated in the inquiry will meet the requirements of the Code for Unfired Pressure Vessels.

CASE NO. 880

(Special Ruling)

Inquiry: Is it permissible under the Code for Unfired Pressure Vessels to use naval rolled brass conforming to U. S. Navy Department Specification 46-B-6-i of the chemical and physical properties given below for unstayed flat heads, cover plates, blind flanges, or special flat parts, the allowable working stress being 10,000 lb per sq in. for metal temperatures not exceeding 300 F?

NAVAL ROLLED BRASS

Copper, per cent	59.00–61.00
Tin, per cent	0.50 – 1.00
Iron, per cent, max	0.10
Lead, per cent, max	0.20
Other impurities, per cent, max	0.10
Zinc, per cent	remainder
Tensile strength, lb per sq in., min	50,000–52,000 depending upon the thickness and width of plates
Yield point, lb per sq in., min	20,000
Elongation in 2 in. for standard type one test specimen, per cent	30–35 depending upon plate thickness and width

Reply: Pending inclusion in the Code of a specification covering naval rolled brass, it is the opinion of the Committee that the material mentioned may be used with a maximum allowable working stress of 10,000 lb per sq in. for metal temperatures not exceeding 300 F.

Books Received in Library

ÄTZHEFT, Anweisung zur Herstellung von Metallschliffen Verzeichnis von Ätzmitteln Verfahren zur Gefügeentwicklung. By A. Schrader. Second enlarged edition. Gebrüder Borntraeger, Berlin, 1939. Linen, 6 × 9 in., 24 pp., charts, tables, 1.60 rm. Etching processes and the solutions used in preparing metallic surfaces for metallographic inspection are presented in concise tabular form, with special attention to the differentiation of intermediate crystal types of aluminum alloys.

AUDEL'S NEW AUTOMOBILE GUIDE for Mechanics, Operators, and Servicemen, With Questions and Answers, by F. D. Graham. Theo. Audel & Co., New York, 1938. Leather, 5 × 7 in., 1499 pp., illus., diagrams, charts, tables, $4. A compendium of information on the theory, construction, and servicing of motor vehicles, including Diesel vehicles. All explanations are presented in simple language, and a multitude of diagrams and other illustrations are included to facilitate practical understanding. Groups of questions and answers accompany many of the sections.

COOPERATION IN RESEARCH by the Staff Members and Research Associates of the Carnegie Institution of Washington, Washington, D. C., 1938. Cloth and paper, 7 × 10 in., 782 pp., illus., diagrams, charts, maps, tables, paper, $4.50; cloth, $5. This volume of papers written by members and research associates of the Carnegie Institution of Washington commemorates the retirement of President John C. Merriam. The papers deal with current problems undertaken in the Institution, emphasizing the results of its investigations and illustrating the effectiveness of cooperation. Among the papers of special interest to engi-

neers may be mentioned: An Adventure in Scientific Collaboration, by Arthur L. Day; Water in Geological Processes, by George W. Morey; Magnetism and the Atomic Nucleus, by M. A. Tuve, L. R. Hafstad and N. P. Heydenburg; Universal Aspects of Atmospheric Electricity, by O. H. Gish; The General Magnetic Field of the Earth and Its Secular Variation, by J. A. Fleming; The Ephemeral Variations of the Earth's Magnetism, by L. V. Berkner and A. G. McNish; and The Scientific Basis of the History of Science, by George Sarton.

EFFECTIVE RETAIL SELLING. By B. F. Baker. American Technical Society, Chicago, 1939. Cloth, 6 × 9 in., 287 pp., illus., tables, $2.25. The principles and practice of retail selling are presented from a practical viewpoint, with emphasis directed toward the complete and accurate knowledge of the merchandise handled. In line with this attitude, a special section on textiles, as representing a large class of merchandise, is included, and a large part of the full bibliography is devoted to merchandise information. There is a list of review questions for the various chapters.

EINFÜHRUNG IN DIE ZAHLENTHEORIE. (Sammlung Göschen, Band 1131.) By A. Scholz. Walter de Gruyter & Co., Berlin, 1939. Cloth, 4 × 6 in., 136 pp., tables, 1.62 rm. Topics covered in this small work on the theory of numbers include the arithmetic of natural numbers, divisibility properties, congruences, quadratic forms and remainders, and various other arithmetical and algebraic operations.

GESTALTUNG VON WÄLZLAGERUNGEN. (Konstruktionsbücher 4.) By W. Jürgensmeyer. Edited by E. A. Cornelius. J. Springer, Berlin, 1939. Paper, 6 × 9 in., 92 pp., diagrams, charts, tables, 4.80 rm. Modern types of ball and roller bearing are defined and described in the first section, with brief discussions of friction, bearing strength, and life period. The second section is devoted to the determination of the factors that affect the size and type of bearing to use, to information concerning the application and installation of bearings, and to brief material on lubrication and packing.

HOW TO BUY, SELL AND BURN COAL. By T. A. Marsh. 5625 Kenwood Ave., Chicago, Ill., 1939. Paper, 5 × 7 in., 97 pp., tables, $1. The author presents in brief form practical information on the selection and utilization of coal, including schematic analyses of causes and remedies for combustion troubles.

INTERNATIONAL CONGRESS FOR APPLIED MECHANICS, FIFTH, Sept. 12–16, 1938, held at Harvard University and the Massachusetts Institute of Technology. Proceedings edited by J. P. Den Hartog and H. Peters. John Wiley & Sons, Inc., New York; Chapman & Hall, London, 1939. Cloth, 9 × 11 in., 748 pp., illus., diagrams, charts, tables, $6. Despite the lack of a subject index, this collection of articles by authorities on applied mechanics is a valuable contribution. The articles are roughly classified. The first large group, on elasticity and the properties of materials, is preceded by three general lectures on the mechanics of solids; the second large group, on mechanics of fluids, is preceded by three general lectures on fluid mechanics; and the third group contains papers on dynamics. The range of specific subjects is wide. The articles have been printed in the original language of the author. A brief review entitled "Three Hundred Years of Mechanics of Materials" appears in an appendix, together with the addresses at the dedication of the Wright Brothers' wind-tunnel.

INTRODUCTION TO CONTEMPORARY PHYSICS. By K. K. Darrow. Second edition. D. Van Nostrand Co., New York, 1939. Cloth, 6 × 9 in., 648 pp., illus., diagrams, charts, tables, $7. The principal advances of recent years in atomic and nuclear physics are described in this treatise and explained with the greatest fullness consistent with mathematics not more difficult than the elements of wave mechanics. Topics discussed include the properties of elementary particles, the correlation of corpuscles and waves, the diffraction of electrons and X rays by crystals, the phenomena of ionization and excitation, the interpretation of spectra, wave mechanics, and the art and science of transmutation. The new edition is much expanded.

INTRODUCTION TO MECHANICS AND HEAT. By N. H. Frank. Second edition. McGraw-Hill Book Co., New York and London, 1939. Cloth, 6 × 9 in., 384 pp., diagrams, tables, $3. Intended for use as a text in an elementary course for scientific and technical students, this book presents a logical, systematic development of physical principles within the fields of mechanics, acoustics, and heat. The use of mathematical methods is emphasized and numerous problems are included.

IRRATIONALZAHLEN. (Göschens Lehrbücherei, Bd. 1.) By O. Perron. Second edition. Walter de Gruyter & Co., Berlin, 1939. Cloth, 6 × 9½ in., 199 pp., tables, 9.80 rm. In this treatise on irrational numbers the field is covered fully from the fundamentals as established by Dedekind through the later developments. Chapter headings include the concept of limits, powers and logarithms, various types of irrationals (continued fractions, series, etc.), algebraic and transcendental numbers, and the approximation of irrationals through the use of rational numbers. There is a bibliography.

KONGRESS FÜR HEIZUNG UND LÜFTUNG (FIFTEENTH), September 21–24, 1938, in Berlin. BERICHT, edited by A. Heilmann. R. Oldenbourg, Munich and Berlin, 1939. Paper, 7 × 10 in., 283 pp., illus., diagrams, charts, tables, 13 rm. This publication contains the technical addresses and reports presented at the Fifteenth Heating and Ventilating Congress, Berlin, 1938. There are also included brief information concerning the Congress and an alphabetical list of the participants.

KRÄFTE IN DEN TRIEBWERKEN SCHNELLAUFENDER KOLBENKRAFTMASCHINEN. (Konstruktionsbücher 2.) By G. H. Neugebauer. Edited by E. A. Cornelius. Julius Springer, Berlin, 1939. Paper, 6 × 9 in., 119 pp., illus., diagrams, charts, tables, 4.80 rm. The forces in the driving gear of high-speed reciprocating engines are investigated from a mathematical viewpoint with reference to smoothness of action and the balancing of the masses. Specific topics include the calculation of dimensions, the determination of weights, moments, centers of gravity, piston and flywheel action, and the forces in one-cylinder engines with applications to multicylinder engines.

MACHINE DESIGN. By S. E. Winston. American Technical Society, Chicago, 1939. Cloth, 6 × 9 in., 333 pp., illus., diagrams, tables, $3. The material selected for inclusion in this elementary textbook is that which the author considers most fundamental to the field of machine design in general. Theory, analysis, and factual information are given concerning bolts and screws, cylinders, riveted joints, shafting and keys, couplings, clutches, belts and pulleys, friction drives, gears, etc. There are many practical examples with detailed solutions.

MÉCANIQUE DES FLUIDES APPLIQUÈ. Vols. 3 and 4. By A. Tenot and A. Caquot. Dunod, Paris, 1939. Bound and paper, 6 × 8 in., diagrams, charts, tables. Vol. 3, 183 pp., paper, 45 fr.; bound, 53 fr. Vol. 4, 106 pp., paper, 28 fr.; bound, 36 fr. These two volumes complete a textbook on applied fluid mechanics intended as a text for engineering colleges and a reference work for engineers. The first volume of the four presents the general principles of the subject and exhibits their applications to turbines, viscosimeters, and lubrication. Volume two is concerned with aeronautical problems. Volume three discusses matters of hydraulics and hydromechanics. The final volume is devoted to the production and utilization of steam. In presenting the material, large use is made of worked-out numerical problems, selected to illustrate practical use of the laws of mechanics to common industrial problems.

MECHANISCHE HAFENAUSRÜSTUNGEN insbesondere für den Umschlag. By O. Wundram. Julius Springer, Berlin, 1939. Cloth and paper, 7 × 10 in., 172 pp., illus., diagrams, charts, tables; cloth, 19.80 rm.; paper, 18 rm. The mechanical equipment for handling of materials at harbors is described in detail with many illustrations, with particular reference to the reshipping of freight. Also discussed are maintenance problems, safety precautions, the expediting of harbor traffic, and cost and other financial considerations.

METALS HANDBOOK. 1939 edition. American Society for Metals, Cleveland, Ohio. Leather, 6 × 9 in., 1803 pp., illus., diagrams, charts, tables, $12.50. This comprehensive volume of metallurgical information has again been revised to cover more completely the subjects of the manufacture, treatment, and application of metals. The general section includes the structure, testing, heat-treatment, and welding of metals; processes, methods, and equipment related to metallurgical operations; and a chapter giving definitions, trade names, and tables of technical data. In the ferrous section the constitution, properties, and testing of iron and its alloys are discussed, and the making, shaping, and treating of iron and steel, including all types of surface treatment, are described. The constitution and properties of other metals are covered in the nonferrous section, as well as the micrography, technology, and uses of the more important ones. There is an extensive index.

MITTEILUNGEN AUS DEN FORSCHUNGSANSTALTEN, Bd. 7, Heft 3, April 1939, pp. 41–66. V.D.I. Verlag, Berlin, 1939. Paper, 8 × 12 in., illus., diagrams, charts, tables, 2.90 rm. The three articles contained in this research communication deal respectively with the weldability of structural steel, with cog-wheel drives for electrically driven rolling mills, and with the determination of wind loads on wide-span roofs by the use of a model.

MITTEILUNGEN DES HYDRAULISCHEN INSTITUTS DER TECHNISCHEN HOCHSCHULE MÜNCHEN, Heft 9. Edited by D. Thoma. R. Oldenbourg, Munich and Berlin, 1939. Paper, 8 × 11 in., 73 pp., illus., diagrams, charts, tables, 5.50 rm. The first two of the four communications included in this publication are concerned with the investigation of flutter phenomena in the case of a cylinder in uniform fluid flow and as evidenced by flags. The two final articles explain and give the results of investigations concerning flow resistance in straight gas pipes and in various types of pipe fittings.

MOTOR BENZOLE, Its Production and Use. By W. H. Hoffert and G. Claxton, with a fore-

word by Sir D. Milne-Watson. Second edition. National Benzole Association, Wellington House, Buckingham Gate, London, S.W.1, 1938. Cloth, 6 × 9 in., 933 pp., illus., diagrams, charts, tables, £2 2s plus postage. A comprehensive treatise on benzole which will be valuable to all engaged in the industry, and also to producers of other motor fuels. The various processes for the production of benzole at coke ovens and gas works are dealt with both in theory and practice. The same is true with respect to benzole recovery and refining methods, including plant design and operation. A brief discussion of the internal-combustion engine accompanies the section covering benzole as a motor fuel. Antiknock values, blends of benzole with other fuels, storage and handling problems, tests, and specifications are given due consideration. A multitude of references is cited.

NATIONAL PHYSICAL LABORATORY REPORT FOR THE YEAR 1938. His Majesty's Stationery Office, London, 1939. Paper, 6 × 10 in., 147 pp., tables. Obtainable from British Library of Information, 50 Rockefeller Plaza, New York, $0.75. In addition to general information concerning the laboratory and its work, this publication presents the reports of the William Froude Naval Laboratory and the departments of physics, electricity, radio, metrology, engineering, metallurgy, and aerodynamics, indicating the state of the current researches.

PIPING HANDBOOK. By J. H. Walker and S. Crocker. Third edition. McGraw-Hill Book Co., Inc., New York and London, 1939. Cloth, 5 × 7 in., 897 pp., illus., diagrams, charts, tables, $6. For the engineer interested in piping design this handbook provides authoritative and accessible data on all phases of the problem. In the revised edition important changes and additions have been made in the chapters on the metallurgy of piping materials, pipe, valves and fittings, heat insulation, steam power-plant piping, and oil piping. Abstracts and references embrace standards and codes of various technical organizations.

PIT AND QUARRY HANDBOOK with which is consolidated the DIRECTORY of Cement, Gypsum, Lime, Sand, Gravel, and Crushed-Stone Plants. Thirty-second edition, 1939. Complete Service Publishing Co., Chicago, 1939. Cloth, 8 × 12 in., 890 pp., illus., diagrams, charts, tables, $10. Some 600 pages of the current edition of this annual work are devoted to technical information concerning processes, practices, machinery, and materials in the nonmetallic mineral industries. There is a directory of cement, gypsum, lime, sand, gravel, and crushed-stone plants, both alphabetically and geographically arranged. Condensed machinery catalogs, a list of trade associations and technical societies, statistical information, trade names, and a buyers' guide are also included.

PRESSURE GAUGES. Indicators, Thermometers, Pyrometers. By J. Smith. Constable & Co., London, 1939. Paper, 5 × 7 in., 144 pp., charts, diagrams, tables, 2s. This little manual gives a concise, clear account of the theory, construction, and use of the ordinary instruments for measuring pressure and temperature, together with some data upon possible sources of error. Barometers, pressure gages, steam- and internal-combustion engine indicators, liquid-level indicators, thermometers, and pyrometers are discussed.

PROBLEMS IN MECHANICS. By G. B. Karelitz, J. Ormondroyd, and J. M. Garrelts. Macmillan Co., New York, 1939. Cloth, 6 × 9 in., 271 pp., diagrams, charts, tables, $2.50. The practical problems collected in this volume cover statics, kinematics, and dynamics in a systematic arrangement, and are of a wide range of difficulty. They are preceded by a concise outline of the theorems which are used in their solution. Answers to nearly all problems are given.

REPORTS ON PROGRESS IN PHYSICS. Vol. 5. Edited by A. Ferguson. The Physical Society, London, S.W. 7; University Press, Cambridge, England, 1939. Cloth, 7 × 10 in., 445 pp., illus., diagrams, charts, tables, 20s. Continuing the series of reports issued by the Physical Society, the present volume deals with advances in physical science up to the end of 1937. It includes reviews of the work in general physics, sound, heat, astronomy, meteorology, optics, spectroscopy, electric wave filters, and atomic physics. More comprehensive articles are included upon the adsorption theorem of J. W. Gibbs, liquid state theories, plastics in industrial physics, instrumental aids for defective hearing, soft X-ray spectroscopy, the use of X rays and Y rays in medicine, absolute electrical measurements, the Geiger counter, quantum mechanics, and the teaching of physics in schools. Each article is the work of a specialist.

SCHWEISSKONSTRUKTIONEN. (Einzelkonstruktionen aus dem Maschinenbau, Heft 9.) By R. Hänchen. Julius Springer, Berlin, 1939. Paper, 8 × 11 in., 123 pp., illus., diagrams, charts, tables, 18.60 rm. The fundamentals of welding processes are covered in the first part of this work, including a discussion of materials and their weldability, the preparation of parts to be welded, seam formation, and graphic symbols representing various welds. In the second and third parts calculations of welded joints for strength and safety, and the form of parts to be welded are considered. In the final section actual jobs of welded construction are described and illustrated.

SHORT HISTORY OF THE STEAM ENGINE. By H. W. Dickinson; printed for Babcock and Wilcox, Ltd., at the University Press, Cambridge, England, 1938. Cloth, 6 × 10 in., 255 pp., illus., diagrams, charts, tables, 15s. This work is a thoroughly readable, admirably balanced account of the development of the stationary steam engine, reciprocating and turbine, and of the steam boiler. The book is the result of long, careful study and corrects many current errors. It will be of interest to both engineers and laymen.

STUDY OF PATENTS ON PETROLEUM CRACKING With Special Reference to Their Present Status. University of Texas Publication No. 3831, Aug. 15, 1938. By D. McKnight, Jr. University of Texas, Austin, Texas, 1938. Paper, 7 × 10 in., 627 pp., diagrams, tables, $3. The complicated patent structures controlled by several large companies in the field of petroleum cracking are examined with regard to their unfairness to the general public and their restraining influence on progress. The principal cracking processes are considered both historically and technically, and a critical review is presented of the history and present status of the general situation. An exhaustive list of U. S. patents on cracking and related methods of conversion is accompanied by patentee and assignee indexes, and there is a tabular summary of cracking-plant litigation.

SUNDIALS, How to Know, Use, and Make Them. By R. N. Mayall and M. L. Mayall. Hale, Cushman & Flint, Boston, 1938. Leather, 6 × 8 in., 197 pp., illus., diagrams, charts, tables, $2. This book gives definite instructions for making and using sundials of many kinds. The text calls for no special mathematical or astronomical knowledge, but is adapted to amateur requirements. A chapter on interesting dials is included, with photographs of many examples.

TOOL MAKING. By C. B. Cole. American Technical Society, Chicago, 1939. Cloth, 6 × 9 in., 413 pp., illus., diagrams, charts, tables, $3.50. The first half of this book describes the toolmaker's personal tools, shop equipment, heat-treating methods and equipment, blueprints, and sketches. The second half is devoted to actual toolmaking processes, and its value is increased by the presentation of many typical jobs, including finished working drawings.

TRANSACTIONS THIRD WORLD POWER CONFERENCE, 1936. 10 vols. Edited by O. C. Merrill. World Power Conference, Superintendent of Documents, Washington, D. C., 1938. Vol. 1, 423 pp.; vol. 2, 700 pp.; vol. 3, 688 pp.; vol. 4, 575 pp.; vol. 5, 696 pp.; vol. 6, 806 pp.; vol. 7, 787 pp.; vol. 8, 825 pp.; vol. 9, 509 pp.; vol. 10, 897 pp. Cloth, 6 × 10 in., illus., diagrams, maps, charts, tables, $2.50 per vol.; $22 per set of 10 volumes; 25 per cent discount for 100 volumes or more in a single order. These ten volumes contain a full record of the meetings of the third Conference, held in Washington, 1936. The theme of the Conference was "The National Power Economy; its physical and statistical basis; its technical, social and economic trends; the relation thereto of the fuel producing, processing, and distributing industries and the electric and gas utilities; practices and policies respecting organization, control, and public regulation; national and regional planning of power development and use; conservation of fuel and water resources; rationalization of the distribution of gas and electricity; and national power and resources policies." Thirty-one countries submitted reports upon one or more of the eighteen topics considered.

VDI-FORSCHUNGSHEFT 395. BERECHNUNG VON STRAHLAPPARATEN. By G. Flügel. V.D.I. Verlag, Berlin, 1939. Paper, 8 × 12 in., 21 pp., illus., diagrams, charts, tables, 5 rm. Jet mechanisms are utilized in many ways in technical work. The methods of calculation employed for the analysis and design of the various forms of this type of apparatus are explained both for use with liquids and for the control of gases.

WASSERKRAFTMASCHINEN. By L. Quantz. Julius Springer, Berlin, 1939. Paper, 6 × 10 in., 152 pp., illus., diagrams, charts, tables, 6.60 rm. This introductory textbook on the design and construction of hydraulic machinery has been revised and modernized. The first two sections deal with general considerations in regard to hydraulic power plants and turbines. The third and largest section is upon the design and construction of the Francis turbine. Section four is upon propeller and Kaplan turbines, and the final section treats of Pelton wheels and other free-jet turbines.

WERKSTOFFE FÜR GLEITLAGER. Edited by R. Kühnel. Julius Springer, Berlin, 1939. Cloth, 7 × 10 in., 427 pp., illus., diagrams, charts, tables, 49.80 rm. The several sections of this book on materials for plain bearings have been written by experts in the particular field. The first section covers general considerations, fundamentals of bearing construction, selection and evaluation of bearing materials, and the testing of bearings. The succeeding sections describe and discuss the production, properties, and behavior of the following materials: synthetic resins; metallic alloys (white metals, bronzes, etc.); hardened lead-bearing metals; and sintered metals.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

British American Engineering Congress Offers Unusual in Technical Papers and Social Events

International Gathering of British, Canadian, and American Engineers Takes Place in New York City, September 4–8

OPPORTUNITIES for the interchange of information and discussion of the progress of engineering in Great Britain, Canada, and the United States will be provided members and guests of the A.S.M.E., who attend the British American Engineering Congress in New York, N. Y., Sept. 4–8. Embodying the Fall Meeting of The American Society of Mechanical Engineers, held jointly with The Institution of Mechanical Engineers of Great Britain, and the Fall Meeting of the American Society of Civil Engineers, held jointly with The Institution of Civil Engineers of Great Britain and The Engineering Institute of Canada, the many joint social functions and excursions of the Congress will permit the formation of lasting friendships as well as the renewal of old ones.

Technical Sessions

The four technical sessions of the mechanical engineers, dedicated to the theme of modern transportation and covering the fields of marine transport, railroads, highways and vehicles, and airplanes, as well as the opening joint session of the Congress on Monday afternoon, Sept. 4, will be held in the Engineering Societies Building, 29 West 39th Street, New York City. The nine technical sessions of the civil engineers, dealing with the topics of construction, highways, sanitation and water supply, parkways, airports, soil mechanics, use of electricity, and structural design, are scheduled to be held at Columbia University, 116th Street and Broadway, New York City.

Participating in two of the mechanical-engineering sessions are several American engineering organizations, namely, the Society of Naval Architects and Marine Engineers in the marine transport session, Tuesday morning, and the Society of Automotive Engineers and the Institute of Aeronautical Sciences in the transatlantic-airplane session, Thursday afternoon. The papers to be presented at the technical sessions of the A.S.M.E. are as follows:

Tuesday Morning, Sept. 5

Marine Transport Session

"Mechanical Engineering Problems in Marine Transport," by Sterry B. Freeman, chief superintendent engineer, Alfred Holt & Co., Liverpool, England. The relative merits of the steam engine and the Diesel engine are compared. The drawbacks and advantages of the two fuels, oil and coal, are contrasted and their effects discussed. Other problems, concerning turbines and boilers, are summarized.

"Some Problems in the Design and Operation of Merchant Vessels," by Robert C. Lee, executive vice-president, Moore-McCormack Lines, Inc., New York, N. Y. A shipowner presents certain technical aspects of ship design and operation as viewed from the standpoint of the executive administration of the merchant marine. Other important matters discussed include safety provisions, crew training, and personnel relations.

Wednesday Morning, Sept. 6

Railroad Session

"Lightweight Passenger Stock," by William A. Stanier, chief mechanical engineer, London, Midland & Scottish Railway, London, England. Developments which have taken place in the last seven years in Great Britain are described, showing the improvements in the conventional British passenger coach. On the constructional side, the layout of the shops and special presses and tools are dealt with.

"High-Speed, Lightweight Trains," by Charles T. Ripley, chief engineer, technical board, Wrought Steel Wheel Industry, Chicago, Ill. American practice and the changes which have occurred during the last five years in high-speed passenger-train cars and in motive power for hauling them, as well as the economic factors which have brought about these changes, are outlined. The probable trend in the future development of these new trains is discussed.

Thursday Morning, Sept. 7

Highway Transportation

"Motor Transport," by E. C. Ottaway, technical officer, London Passenger Board, London, England. The subject is treated in two parts; the first part discusses the influences which encourage or restrict the engineer in his quest for improvement, serving as a background against which the development of the motor vehicle in Great Britain, described in the second part, may be better understood.

"Problems of the Highway User in the United States," by Frederick C. Horner, assistant to the chairman, General Motors Corporation, New York, N. Y. The present-day highway problem is made up of many elements, namely, cost of construction, ability of highway users to pay for highways as they are built or during their life expectancy, the kind of taxes providing revenue to pay for highways, types of roads required, competition between transportation systems, and kindred matters. These are all analyzed and suggestions made for their solution.

Thursday Afternoon, Sept. 7

Transatlantic-Airplane Session

"Transatlantic Air Transport With Particular Reference to Flying Boats," by A. Gouge, Short Bros., Rochester, England. The author outlines several designs for airplanes and seaplanes for transatlantic service, and is of the opinion that, largely on account of take-off and landing problems, flying boats will be used. Consideration is given to the influence of improvements in materials, high-altitude research, and the compression-ignition engine on the future development of large transatlantic flying boats.

"The Trend of Air Transportation," by Edmund T. Allen, director of aerodynamics and flight research, Boeing Aircraft Company, Seattle, Wash. Since 1925, the air-transportation industry has advanced through successive stages of growth and development until today it is in the state of transition between the pioneering period and that of mature growth. Every phase of this development is treated comprehensively in order that an understanding may be gained of the future possibilities of air transport and the lines along which it will advance.

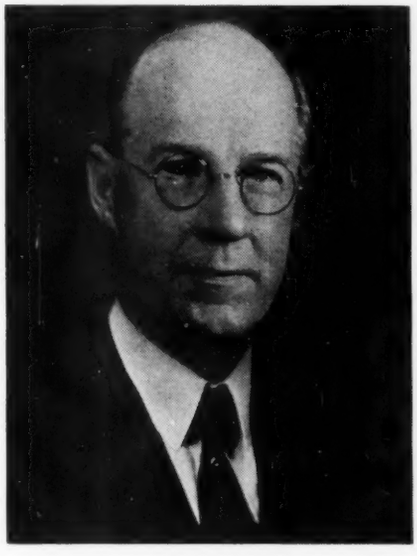
Joint Social Functions

The Congress is unique in that it is the first such joint engineering affair ever held in New York City and in that so many of the social events and inspection trips will center around the exhibits of the New York World's Fair, the largest and most representative exhibition

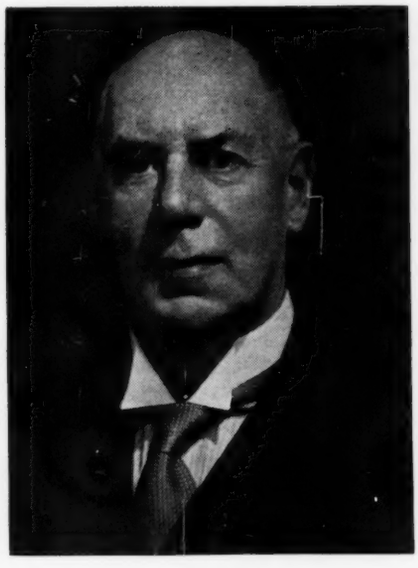
D. H. SAWYER
President, Am.Soc.C.E.

H. W. MCKIEL
President, E.I.C.

W. J. E. BINNIE
President, Inst.C.E.



A. G. CHRISTIE
President, A.S.M.E.



E. B. BALL
President, I.Mech.E.

of its kind ever held. The week's activities of the Congress are something which no engineer or his wife can afford to miss, especially the joint social functions.

Opening Session

The opening session on Monday afternoon, Sept. 4, in the Engineering Societies Building, presided over by President A. G. Christie, of the A.S.M.E., will be the occasion when President Donald H. Sawyer, of the A.S.C.E., will formally welcome members and guests to the Congress. Greetings will be presented in behalf of their societies by President William J. E. Binnie, of The Institution of Civil Engineers, President E. Bruce Ball, of The Institution of Mechanical Engineers, and President H. W. McKiel, of The Engineering Institute of Canada. Following this very impressive event, there will be a tea and reception for the British and Canadian guests. After an inspection of the 16-story Engineering Societies Building, including offices of the various engineering societies and the world-famous Library, a tablet in memory of Calvin W. Rice, former secretary of the A.S.M.E., will be unveiled in the lobby of the building. The evening will be devoted to an informal dinner in the Rainbow Grill atop the 67-story R.C.A. Building in Radio City, followed by a visit to one of the N.B.C. studios to see and hear a broadcast.

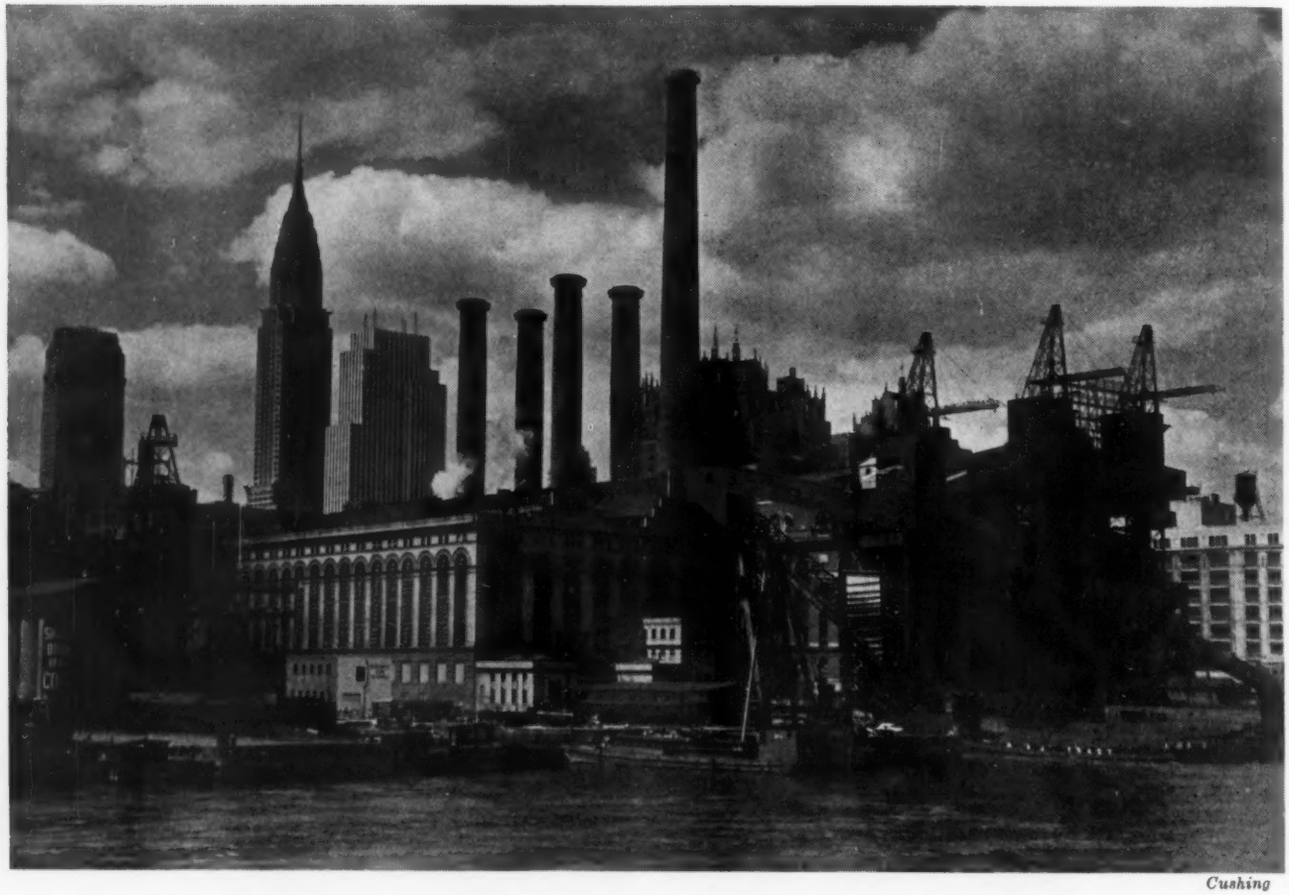
Boat Excursion

On Tuesday afternoon, September 5, the engineers and their wives will board the S.S *Peter Stuyvesant* for a trip up the Hudson River under the George Washington Bridge, then returning along the New Jersey shore line to Staten Island and along its pier line to The Narrows, and continuing north along the Brooklyn shore line up the East River to Whitestone Landing, where the party will be transferred by motor coaches to the World's Fair. Buffet luncheon and tea will be served on board the ship. Dinner at the Casino of Nations, World's Fair, will be the prelude to a trip through the fair grounds.

Wednesday afternoon will give those who are interested an opportunity to inspect the comprehensive display at the World's Fair railroad exhibit. There will be a tea for members and their ladies in the latter part of the afternoon at the Faculty Club of Columbia University.

Banquet and Dance

The formal congress banquet and dance will be held on Wednesday evening at The Waldorf-Astoria. Dr. Nicholas Murray Butler, presi-



Cushing

THE WATERSIDE PLANT OF THE CONSOLIDATED EDISON COMPANY—A VIEW FROM THE DECK OF AN EAST RIVER STEAMER WITH BUILDINGS SHOWN IN THE BACKGROUND, FROM LEFT TO RIGHT, CHANIN, CHRYSLER, DAILY NEWS, AND TUDOR CITY

dent of Columbia University, will act as toastmaster. Speakers from the three countries represented at the Congress include Dr. Charles E. Inglis, professor of engineering, Cambridge University, the Hon. Charles D. Howe, minister of transport, Ottawa, Canada, and Dr. Gano Dunn, president, J. G. White Engineering Co., New York, N. Y. C. A. J. Parmentier will play organ selections during the dinner and the orchestra of George G. Ellner will furnish the music for dancing after the dinner.

Columbia University Celebration

Meeting at the McMillin Theater of Columbia University on Thursday evening, the Congress will participate with the University in celebrating the 75th anniversary of the founding of the School of Engineering of Columbia University. After greetings to guests and alumni by Joseph W. Barker, dean of engineering, Prof. James K. Finch will give a short history of the school. The address of the evening will be by Willard T. Chevalier, vice-president, McGraw-Hill Publishing Co., Inc., whose topic, "Government, Economics, and the Engineer," should prove of great interest to every one.

Honors and Closing Session

Engineers' Day at the World's Fair will be celebrated by Congress participants on Friday, Sept. 8. Meeting in the Hall of Music in the morning, the five engineering societies will confer honors on distinguished engineers of Great Britain, Canada, and the United States. President Sawyer of the A.S.C.E. will preside. "Have Engineering and Science Gone Too Far?" will be the subject of the address by Charles F. Kettering, president of General Motors Research Corporation. In closing the session, remarks will be made by President Binnie, of the Inst.C.E., President Ball, of the I.Mech.E., and President McKiel, of the E.I.C. Then, President Christie, of the A.S.M.E., will make the closing address.

All Engineers Welcome

George L. Bourne, chairman of the M.E. General Committee, and Robert W. Sawyer, 3d, chairman of the C.E. Arrangements Committee, extend a cordial invitation to all American engineers, both members and nonmembers of the participating bodies, to take part in the British American Engineering Congress of 1939. Mrs. George W. Farny, general chairlady of the Ladies' Committees, promises attending ladies the best time they have ever had.

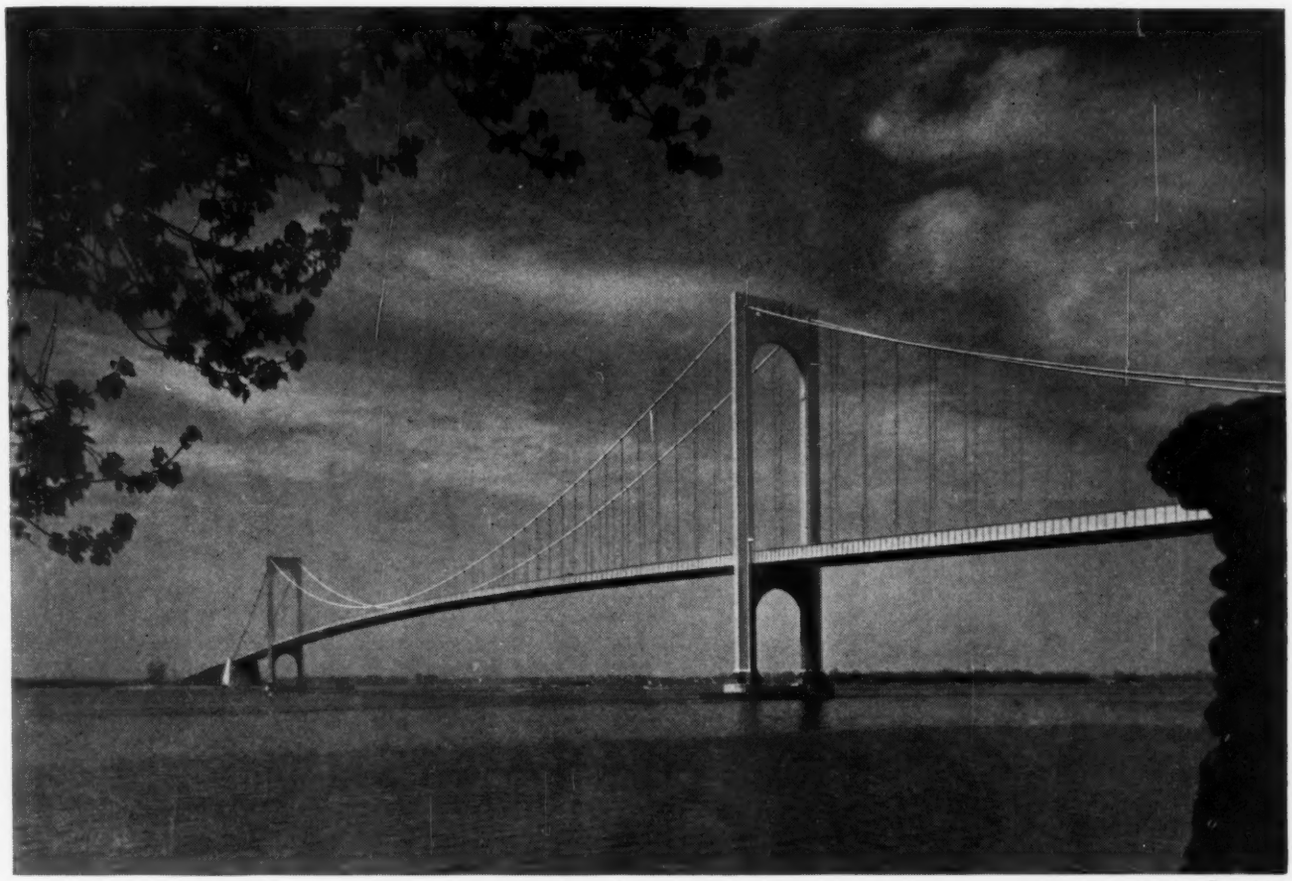
Headquarters of the various groups during the Congress will be located as follows: A.S.M.E., Engineering Societies Building; A.S.C.E., Low Memorial Library, Columbia University; I.Mech.E., Pennsylvania Hotel; A.S.M.E. Ladies' Committee, Engineering Societies Building; and A.S.C.E. Ladies' Committee, The Women's Faculty Club, 410 West 117th Street, New York City.

Woman's Auxiliary to A.S.M.E. Now Has Five Local Sections

BECAUSE of the great interest of wives of members of the A.S.M.E. in the work of the Woman's Auxiliary to the A.S.M.E. in New York and other cities, the national group has authorized the formation of local sections of the Auxiliary in Baltimore, Cleveland, Philadelphia, New York, and now, Los Angeles.

Loan and Scholarship Funds

The major functions of the local and national groups are the entertainment of the ladies at National Meetings of the A.S.M.E. and, in between meetings, conducting teas and benefits for the purpose of raising money for the Educational Loan Fund, which is used to grant loans to needy mechanical-engineering students. Any Local Section of the Society may recommend a student for a loan by filling out a form which can be obtained from the Auxiliary. At the last meeting of the National Auxiliary, a suggestion was made and accepted that a scholarship be established in memory of Calvin W. Rice to be awarded to worthy for-



Cushing

THE WHITESTONE SUSPENSION BRIDGE CONNECTING WHITESTONE LANDING, LONG ISLAND, WITH OLD FERRY POINT IN THE BRONX, N. Y. IT SPANS 2300 FT WITH TWO SIDE SPANS OF 735 FT AND COST $18,000,000

eign students who desire to complete their engineering education in the United States. A benefit for the scholarship fund will be held in New York in October.

Women Prepare Congress Program

With Mrs. George W. Farny acting as general chairman of the mechanical- and civil-engineering women's committees of the British American Engineering Congress, to be held in New York, Sept. 4–8, a complete program has been worked out for the entertainment of the ladies from here and abroad. A summary of the program follows:

Monday, Sept. 4—Tea at Engineering Societies Building, dinner at Rainbow Grill, Radio City, and visit to broadcasting and television studios.

Tuesday, Sept. 5—Visit to American Museum of Natural History, and boat trip around Manhattan and to the World's Fair.

Wednesday, Sept. 6—Shopping tours, visit to Morgan Library, luncheon at Woman's Republican Club or Engineering Woman's Club, and banquet at The Waldorf-Astoria.

Thursday, Sept. 7—Motor trip to West Point, luncheon at Bear Mountain Inn, and tea at Stevens Institute of Technology.

Friday, Sept. 8—All day at the World's Fair, joining in the honors and closing session of the Congress.

A.S.M.E. Wood Industries Division to Hold National Meeting in Boston, Mass., Oct. 12–13

Dr. Hugh P. Baker Speaker at Banquet; Technical Sessions in Mornings; Afternoon Inspection Trips

PLANS are well along for the twelfth national meeting of the Wood Industries Division of The American Society of Mechanical Engineers to be held in Boston, Mass., October 12 and 13, with technical sessions scheduled for the mornings and inspection trips for the afternoons.

Thursday's Events

On Thursday morning, October 12, three papers are to be given. Louis J. Bosse, managing director of the Hardwood Dimension Manufacturing Association, Louisville, Ky., will talk on "The Economic Status of the Hardwood Dimension Industry;" J. W. Medley, technologist in wood products of the National Bureau of Standards, Washington, D. C., will discuss "The Development of Dimensional Control and Tolerances for Wood Products;" and Conrad Pantke, of Roof Structures, Inc., New York, will have as his subject "Modern Timber Construction."

At the luncheon on Thursday reports will be given by the various committees of the Wood Industries Division concerning the progress of their work. Trips to local woodworking plants are being arranged for the afternoon.

Dr. Hugh P. Baker Speaker at Banquet

The annual banquet of the Division will be held on Thursday evening when the speaker of the evening will be Dr. Hugh P. Baker, president of the Massachusetts State College, whose address will be "A Program for More Effective Cooperation Between the Woodworking Industries and the Education of Engineers." A technical paper will also be presented by Henry S. Jones, production engineer of the Globe-Wernicke Co., Cincinnati, Ohio, dealing with "A Plan of Foremanship Training."

Two papers are to be presented on Friday morning: The first will be on "Superpressed

Plywood," by Thomas D. Perry, development engineer, Resinous Products & Chemical Co., Inc., Philadelphia, Pa.; the second on "Standardized Homes of Wood and Plywood" will be by John E. Birchard, director of A. S. Bemis Foundation, Massachusetts Institute of Technology, Cambridge. The Executive Committee of the Division will hold its luncheon at noon on Friday to discuss its plans for 1940 while the afternoon will be devoted to sightseeing trips about Boston.

H. H. Morgan Installed as President of A.S.T.M.

H. H. MORGAN

H. H. MORGAN, a member of A.S.M.E., and manager of the rail- and track-fastenings department, Robert W. Hunt Co., Chicago, Ill., was installed as president of the American Society for Testing Materials at the annual meeting held in Atlantic City, June 26 to 30. Mr. Morgan is well known to A.S.M.E. members because of his work for the Society on the Sectional Committee on standardization of Code for Pressure Piping, Subcommittee No. 7 on Piping Materials and Identification, as chairman of the Sectional Committee on Wrought Iron and Wrought Steel Pipe and Tubing, as chairman of Subcommittee No. 1 on Plan, Scope, and Editing, Mechanical Standards Committee, and Subgroup on Basic Formulas.

The registration for the meeting amounted to 1354. There were about 225 meetings of committees and in the 22 sessions (including several round-table discussions) some 110 papers and reports were presented. The round-table get-togethers covered such subjects as the effect of subatmospheric temperatures on metals, methods and technique of spectrochemical analysis, freezing and thawing tests.

Since this is the year when the A.S.T.M. will issue its triennially published Book of Standards, the intense activity of Committees resulted in many recommendations. All told, some 116 existing tentative specifications were recommended for adoption as standards, and revisions of standards which had been published previously for consideration are to be referred to letter ballot for adoption in 101 standards.

In his presentation of the 14th Edgar Marburg Lecture on "Stress, Strain, and Structural Damage," H. F. Moore, member A.S.M.E., and professor of engineering materials, University of Illinois, considered four types of structural damage due to mechanical causes: (1) Elastic deformation, (2) damage by inelastic action, (3) fracture, and (4) damage by continuing deformation or creep. He felt it advisable to limit discussion to these four types and not to consider subjects of corrosion fatigue, impact, and wear.

Manual of Metal-Cutting Data to Be Issued by A.S.M.E.

IN THE FALL The American Society of Mechanical Engineers will publish a "Manual on Cutting of Metals" that will be of vital interest to every machine shop in the United States. The manual amplifies and brings up to date the work of Frederick W. Taylor, pioneer in this field, and represents the culmination of a project that has been under way for some time.

Taylor's Work Provides Background

In 1908 Frederick W. Taylor gave as his presidential address before The American Society of Mechanical Engineers, the classic "On the Art of Cutting Metals." This, coupled with his invention, with the cooperation of Maunsel White, of high-speed steel revolutionized machine-shop practice throughout the world. Taylor's work was confined to the cutting of cast iron and steel. Little or no research had been done on the nonferrous metals and on alloy steel. Late in 1916, a group of men in the Engineers' Club in New York were discussing the profound effect that Taylor's work had produced in the metal-working field and comment was made on the lack of data on the machining of the brasses, bronzes, and other nonferrous metals. It was observed that the extension of the work of Taylor into these fields would have an effect on machine-shop practice secondary in importance only to the original investigation. The upshot of this conversation was an undertaking to set up ways and means of starting a research to supplement Taylor's "On the Art of Cutting Metals."

The entry of the United States into the World War stopped this effort, and the group was scattered. In 1930 a few of them happened again to meet at the Engineers' Club. The project was revived, and finally was sponsored by The American Society of Mechanical Engineers. A special research committee on "Metal Cutting Data" was formed and plans were laid to discover the laws underlying the cutting of the alloys. The preliminary studies, however, revealed that great advances had been made in tool steels since Taylor's day and that new tool materials such as the cemented carbides had come into use. Furthermore, new materials of engineering, notably the alloy steels, were available, whose properties were quite different from those in use in the first decade of the century. The committee decided that the wise course would be to bring Taylor's work up to date before proceeding into new fields.

Now, after six years of unremitting effort, the committee has completed this phase of its work. Every available research by investigators all over the world has been studied. Experimental work in large volume has been done to verify the results of other investigators and to fill gaps in existing data. The cooperation of The Engineering Foundation, Stevens Institute of Technology, and machine-tool builders and users in a variety of fields was enlisted.

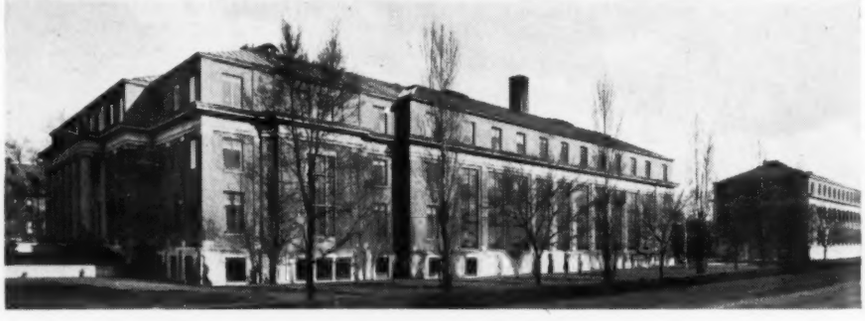
Report Called "Tool for Shop Use"

The report of the committee is now on the press and will be available in the fall of this year. It is unique in that it is in a form that will permit its immediate use in the shop as a basis for determining feeds, speeds, and rate setting. In short, it is a tool for shop use.

The tables in the report show the feeds and speeds that can be used with various depths of cut in machining all of the steels in common use, including some of the alloy steels. In addition, a table of conversion factors is given that covers practically all of the ferrous metals used in engineering. By means of these conversion factors, feeds and speeds can be determined for any ferrous metal that is likely to be encountered in the machine shop.

In addition to these tables, the report contains a wealth of material on the laws underlying the cutting of metals, the mathematics of these laws, and tool materials, forms of tools, and a vast amount of information of immense value to the shop.

The report is authentic. The values in the tables have been tested in a number of shops under actual conditions. The results uniformly show that the values are conservative, and yet that the improvement in shop performance ranges from 10 to 25 per cent better than the usual, everyday good shop practice. It is believed that the "Manual on Cutting of Metals" will be a worthy successor to "On the Art of Cutting Metals."



BATTELLE MEMORIAL INSTITUTE

(Devoted to research in fuels, metallurgy, ceramics, and chemistry, it will be of interest to engineers attending the Third Annual Joint Meeting of the A.S.M.E. Fuels Division and the A.I.M.E. Coal Division in Columbus, Ohio, Oct. 5–7. For program of Meeting see page 695.)

Courtesy Columbus Chamber of Commerce

AIR VIEW OF COLUMBUS, OHIO, SHOWING STATE CAPITAL

Coal Utilization to Feature Fuels Division Meeting

Meets Jointly With A.I.M.E. Coal Division, Columbus, Ohio, Oct. 5–7

COAL UTILIZATION is to be the central topic of the Third Annual Joint Meeting of the Fuels Division of the A.S.M.E. and the Coal Division of the A.I.M.E. to be held at the Deshler-Wallick Hotel, Columbus, Ohio, Oct. 5-7. The program committee, composed of H. O. Croft, State Univ. of Iowa, H. F. Hebley, Commercial Testing and Engineering Co., H. E. Nold, Ohio State University, J. E. Tobey, Appalachian Coals, Inc., and R. A. Sherman, Battelle Memorial Institute, chairman, recently announced the completion of the technical program centering about this general subject.

One session is to be devoted to the utilization characteristics of coal as related to mining methods, with separate consideration of underground and strip-mining operation. Coal utilization in steam generation will be discussed in a second session, including "Coordination of Fuel Engineering From Mine to Consumer," "A Proposed Code for Testing Coal," and "Recent Developments in Equipment for Burning Anthracite Coal." The firing of open-hearth steel furnaces with pulverized coal, the measurement of pressures during the carbonization of coal, and coal and gas will be covered in the third Symposium. The fourth and concluding technical session will hear papers on firing open-hearth steel furnaces with pulverized coal, the viscosity of coal-ash slags, and photography in boiler furnaces. Slides and motion pictures will illustrate the last topic. An address on the relation of the bituminous-coal and manufactured-gas industries is planned for one of the luncheon sessions.

A gridiron battle between The Ohio State University and the University of Missouri will provide relaxation on Saturday afternoon following the two-day technical program.

Members of the Fuels Division of the Society will be mailed the final program, together with reservation blanks for hotel accommodations and football tickets, in the early part of September. Others may request these directly from R. A. Sherman, Battelle Memorial Institute, Columbus, Ohio. The detailed program follows:

Program

THURSDAY, OCTOBER 5

9:00 a.m. Registration

Opening Session

10:00 a.m.

Chairman, C. A. Gibbons, chairman of A.I.M.E Coal Division, and *vice-chairman*, H. F. Hebley.

Symposium: Relation of Mining Methods to Characteristics of Coal.

Bituminous Deep Mining, by Thomas S. Downing, Jr., Philadelphia Electric Company.

Bituminous Strip Mining, by William C. McColloch, United Electric Company.

Anthracite Deep Mining, by John Buch, The Pennsylvania State College.

Luncheon Session

12:30 p.m.

Chairman, A. C. Fieldner, Bureau of Mines.

Second Session

2:00 p.m.

Chairman, L. C. Bosler, chairman of A.S.M.E Fuels Division, and *vice-chairman*, D. R. Mitchell.

"Coordination of Fuel Engineering From the Mine to the Consumer," by T. R. Workman, fuel engineer, West Virginia Coal and Coke Co.

A Code for Testing Coal, by R. L. Rowan, fuel engineer, General Coal Co.

Recent Developments in Equipment for Burning Anthracite, by William Lloyd, Combustion Engineering Co.

Dinner

7:00 p.m.

Address on some economic or sociological aspects of coal production and utilization.

FRIDAY, OCTOBER 6

Third Session

9:30 a.m.

Chairman, J. E. Tobey, and *vice-chairman*, G. B. Gould.

Firing Open-Hearth Steel Furnaces With Pulverized Coal, by J. P. Kittredge, National Malleable and Steel Castings Co.

The Measurement of Pressures During the Carbonization of Coal, by C. C. Russell, Engineering and Construction Division, Koppers Co.

Address on "Coal and Gas," by A. M. Beebee, general superintendent, gas department, Rochester Gas and Electric Co.

Luncheon Session

12:30 p.m.

Chairman, E. G. Bailey. Address on Coal Research in England.

Closing Session

2:00 p.m.

Chairman, M. D. Engle, and *vice-chairman*, H. E. Nold.

The Viscosity of Coal-Ash Slags, by P. Nicholls and W. T. Reid, Bureau of Mines.

Notes on the Photographic Study of Furnace Combustion, by A. A. Markson and W. H. Dargan, research department, Consolidated Edison Co., to be illustrated with still and motion pictures and followed by discussion in the form of motion pictures by representatives of Combustion Engineering Co., University of Illinois, and others.

SATURDAY, OCTOBER 7

9:00 a.m.

Inspection trips to Jeffrey Manufacturing Co., Battelle Memorial Institute, and new boiler room of the Municipal Light Plant.

2:00 p.m.

Football game, The Ohio State University versus University of Missouri.

Cornell University to Celebrate Centennial of Birth of Dr. Thurston, First A.S.M.E. President

One-Day Celebration to Be Held at Ithaca, N. Y., Oct. 25; A.S.M.E. Past-Presidents Durand and Davis to Speak

THE CENTENNIAL of the birth of Robert Henry Thurston, the great pioneer in engineering education and first president of the A.S.M.E., will be celebrated on Oct. 25 at Ithaca, N. Y., by Cornell University in cooperation with the A.S.M.E. Delegates from American and Canadian engineering schools, technical and academic societies in this country and abroad of which Dr. Thurston was a member, and other organizations, together with the alumni of Stevens Institute and Cornell University from the classes of Thurston's time will be special guests. Members of the A.S.M.E. will be welcome.

The celebration will be a one-day affair, including an academic procession and convocation in the morning, an exhibit of Thurston's publications and of laboratory apparatus he designed, and other events, details of which will be announced later. James W. Parker of Detroit is the official representative of the A.S.M.E. on the committee on arrangements. The tentative program, announced by Cornell University, follows:

9:30 a.m. Academic procession.

10 a.m. Memorial Ceremony in Bailey Hall, Dr. Edmund Ezra Day, president, Cornell University, presiding

Speakers

Dr. James Pickwell Adams, vice-president, Brown University

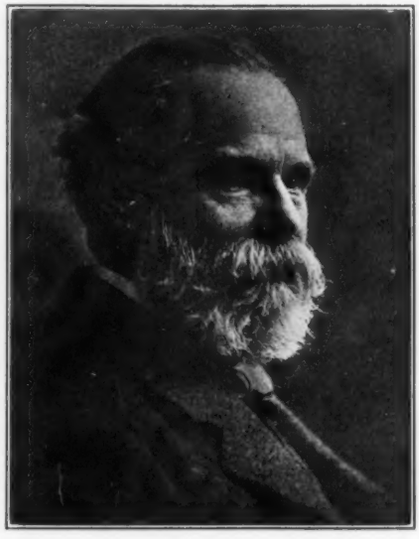
Admiral Wilson Brown, superintendent, U. S. Naval Academy

Dr. Harvey N. Davis, president, Stevens Institute of Technology, and past-president of the A.S.M.E.

Dr. William Frederick Durand, emeritus professor of mechanical engineering, Leland Stanford University, and past-president, A.S.M.E., and author of "Robert Henry Thurston: a Biography."

Dean S. C. Hollister, College of Engineering, Cornell University

The ceremony is designed to recall and emphasize the distinguished contributions of Dr. Thurston to engineering education, where the broad principles he laid down are still the guiding force today. While teaching at Annapolis, where the U. S. Navy transferred him after his period of active service in the Civil War, Thurston began to develop a plan for training engineers that would supplant the then current vocational courses in mechanic arts. He put his plan into operation at Stevens Institute between 1871 and 1885, founding the first mechanical laboratory for purposes of instruction, assembling and at times inventing the necessary apparatus, and writing a pioneer manual, "The Materials of Engineering," for his students. In 1885, President Andrew D. White called Dr. Thurston to Cornell, where for 18 years he directed instruction in mechanical engineering, setting up a more comprehensive laboratory, writing additional textbooks, surrounding himself with able teachers, and establishing educational standards and programs that set the pattern for modern engineering education. His biographer, Dr. W. F. Durand, has stated that his work at Cornell gave "to the College prestige and standing in the very front rank of the engineering schools of the country and of the world."



ROBERT HENRY THURSTON

Throughout his career as a teacher and administrator, Dr. Thurston continued the practice of engineering and wrote voluminously for technical publications. He was one of the founders and the first president of The American Society of Mechanical Engineers, serving two terms; three times a vice-president of the American Association for The Advancement of Science; and a member of the American Society of Civil Engineers, and of numerous other technical and academic organizations here and abroad. He also served on several important state and federal commissions.

Dr. Thurston was considered an authority on materials of construction, steam engines and boilers, and the history of engineering, as well as on the philosophy of education. His most widely known work, "A History of the Growth of the Steam Engine," published originally in 1878, is scheduled for republication this year as part of the celebration of the Centennial of his birth. Born in Providence, Rhode Island, on Oct. 25, 1839, he died in Ithaca, N. Y., on Oct. 25, 1903.

Bibliography on Machining of Wood Available From A.S.M.E.

THE Wood Industries Division of the A.S.M.E. has just prepared a 74-page booklet, "A Bibliography on the Machining of Wood," as a preliminary step in a proposed program of research in the machining of wood sponsored by the Division. Although wood machining has been practiced for thousands of years, the subject has received relatively little scientific and engineering attention. The object of the bibliography is to list references that will assist in the engineering investigation of problems of machining, particularly research in the analysis of forces exerted and the energy required in chip formation, improvement of the surfaces of finished products, reduction of machining waste, and improvement in the life and safety of saws, knives, and abrasives.

Copies of the bibliography may be obtained from A.S.M.E. headquarters, 29 West 39th St., New York, N. Y., by members for $1 each, and by nonmembers for $1.25.

Machine Shop Practice Division to Meet in Cleveland

THE Machine Shop Practice Division will hold a session Thursday evening in the Cleveland Hotel, Cleveland, Ohio, at 8 p.m., October 5, as one of the cooperating bodies of the Machine Tool Congress to be held in that city in conjunction with the Machine Tool Exposition, October 4 to 13. Prof. A. G. Christie, President of the A.S.M.E., will preside at the meeting and present an introductory address. Two papers dealing with machine-tool frames and beds will be read. Frank J. Dost, of the Sterling Foundry Co., Wellington, Ohio, will speak on "Making Better Machine-Tool Castings;" and Fred Volz, of the Lakeside Bridge & Steel Co., Milwaukee, Wis., will speak on "Welded Frames for Machine Tools." It is expected that a number of engineers, well versed in the metallurgy of cast iron as well as in the use of welded construction, will participate in the discussion of these papers.

Iron & Steel Engineers Meet in Pittsburgh, Pa., Sept. 26–29

THE Association of Iron and Steel Engineers has extended a cordial invitation to members of the A.S.M.E. and participants in the British American Engineering Congress to attend the Association's annual convention and exposition in Pittsburgh, Pa., Sept. 26–29. The technical program includes 25 papers on subjects pertaining to the iron and steel industry. Further information may be obtained from the managing director, Brent Wiley, Empire Building, Pittsburgh, Pa.

Junior Group Activities

Robert Zimmerman, Junior A.S.M.E., Wins $2750 Scholarship

R. M. ZIMMERMAN

ONE of the ten young executives nominated by industries in all parts of the country for administrative training at M.I.T. for one year under a grant by the Alfred P. Sloan Foundation was Robert M. Zimmerman, Junior A.S.M.E. The value of his scholarship is $2750. A graduate of engineering at Purdue University in 1932, Bob began as a "grease monkey" with Transcontinental and Western Air, Inc., in its shops at Kansas City, Mo., and in 1934 was made project engineer. He has represented T.W.A. in construction of airports at Columbus; Chicago; Winslow, Arizona; Pittsburgh; Harrisburg; Philadelphia; Newark; and, only recently, the new $35,000,000 North Beach Airport in New York City. The group of scholarship winners started study in business administration and economics at M.I.T. on June 15.

Juniors Invited to Assist Professional Divisions

JUNIORS of the A.S.M.E., who are interested in a specialized phase of mechanical engineering, now have an opportunity to broaden their knowledge of the subject, as a result of a suggestion made by the Standing Committee on Professional Divisions to Divisions advising them to place one or more Juniors on their executive Committees. Consequently, some requests have already been received from some Divisions for the names of Juniors who would be interested in being appointed to their executive committees.

The number of Juniors required by each Division is as follows: Materials Handling, several in New York and one in Boston; Aeronautics, one in New York; Oil and Gas Power, several from New York and other parts of the country; Railroad, one in New York; and Textile, one in Newark, N. J. Applications, showing qualifications, from Juniors in all parts of the country for these appointments, as well as for probable ones in the following Divisions: Applied Mechanics, Fuels, Graphic Arts, Hydraulic, Iron and Steel, Machine Shop Practice, Management, Petroleum, Power, Process Industries, Wood Industries, and Heat Transfer, should be sent, on or before Sept. 15, 1939, to Leslie Zsuffa, A.S.M.E. headquarters, who will forward them to the chairmen of the proper Divisions.

Kansas City Juniors Have Interesting July Meeting

THE regular monthly meeting of Junior members of A.S.M.E. was held on July 11, 1939, in the KCP & L Co. Building at 8:00 p.m. with twenty members present.

Mr. Albert Will, of the Junior group, spoke on "Public Relations." He dealt with the importance to any company of a friendly public. Mr. Jess Carmichael, also of the Junior group, spoke on "Gasoline Lead Analysis by the New HCl Method." The old method of lead analysis by precipitation with bromine in carbon-tetrachloride solution required cooling with ice which usually resulted in condensation of moisture inside the beaker. Partial solution of lead bromide resulted with consequent error in the determination. The new method involves boiling with hydrochloric acid to form lead chloride, subsequent removal of excess acid, and titration with ammonium molybdate in the presence of an indicator.

Mr. C. E. Brown, of Burns & McDonnell Engineering Co., was the guest speaker of the evening. His subject was "Precision." The interpretation Mr. Brown placed on this subject was that in any particular situation no measurement need be more accurate than would correspond to the one where the greatest inaccuracy necessarily existed. The art of engineering in design as well as in practice cannot obtain results actually any more precise than the data upon which they are based. Cognizance of this fact can save the engineer a great deal of needless time and effort.

Metro Juniors Are Members of Panel at Rutgers Conference

THE Junior Group of the Metropolitan Section, A.S.M.E., will be represented by H. G. Oliver, Jr., O. B. Schier, II, George L. Williamson, and Leslie F. Zsuffa, who will take part in the afternoon panel discussion

"TEMPLE OF ZEUS"

(Photograph by A. C. Giovan, student member A.S.M.E., awarded first prize at the 1939 A.S.M.E. Midwest Student Group Meeting in Chicago, Ill., April 17–18, 1939.)

Cash Prizes to Be Awarded at A.S.M.E. Photo Exhibit

Entry Forms Available From Philadelphia Committee

MEMBERS of the Society and their friends are invited to submit technical and non-technical photographs for showing at the Fourth Annual A.S.M.E. Photographic Exhibit to be held during the 1939 Annual Meeting of the Society in Philadelphia, Dec. 4–8, 1939. Prints mounted on 16 × 20-in. light-colored cards should be sent, on or before Nov. 30, 1939, to the A.S.M.E. Photo Exhibit Committee, The Engineers Club, 1317 Spruce Street, Philadelphia, Pa., together with an entry fee of $1 to cover return postage, insurance, and wrapping. This year, MECHANICAL ENGINEERING will award cash prizes of $5, $3, and $2, and honorable-mention citations for all photographs selected for reproduction on the cover and in the editorial pages of the Society's journal. Official entry forms may be secured from the Committee in Philadelphia.

of the 14th Annual Industrial Conference, to be held at Rutgers University, Sept. 7, 1939. Based on figures of previous conferences, the audience will consist of about 400 young college graduates and 150 major executives of manufacturing companies located in northern New Jersey and Metropolitan New York. A.S.M.E. members are cordially invited to attend.

Starting at 2:15 p.m., Mr. Schier will open the panel discussion by presenting a 15-minute summary of recent reports of the E.C.P.D. and other organizations on the problems of young college graduates. Then, taking as their subject, "The Young College Graduate in Industry Considers His Problems and Objectives," members of the panel will discuss such topics as first years of adjustment into industry, company policies, analyzing the "boss," analyzing oneself in the light of his objectives, and problems of opportunities, promotions, salaries, change of position, marriage, friendships, and community relations.

Further information about this Conference, in which the Junior Group is taking an active part, may be obtained from A.S.M.E. headquarters or from Prof. J. H. Vertrees, University Extension Division, Rutgers University, New Brunswick, N. J.

Los Angeles Juniors Award $25 in Prizes for Students

ON MONDAY evening, May 8, a joint meeting of the Student Branches of the University of Southern California and the California Institute of Technology was held under the auspices of the Los Angeles Junior Group, which donated $25 in prizes for the best papers presented at this meeting by student members.

John W. Black, C.I.T., won first prize of $15 with his paper on "Pitot-Tube Traverses." Robert Bridges, U.S.C., received $10 as second prize for his paper describing a method of increasing power in internal-combustion engines. For his paper, "Aerodynamics of Sails," Mitchell Homann received honorable mention.

With the Student Branches

A.S.M.E. Student Branches in 117 Schools Close 1938–1939 With 6061 Members

STUDENT BRANCHES of the A.S.M.E. in 117 engineering schools throughout the United States and Canada broke all records during the school year of 1938–1939 with a total membership of 6061 students. The figure for 1937–1938 was 5229. Purdue University maintained its lead of last year by increasing its membership from 181 to 308. In the race for second place, the University of Michigan, which held it last year, lost it to the University of California and dropped to fifth as a result of the active membership campaigns put on by the University of Illinois and Armour Institute of Technology.

Especially noteworthy were the records of Texas A.&M. College, which increased its number of members from 78 to 137; Cooper Union, 45 to 109; University of Minnesota, 59 to 107; R.P.I., 55 to 106; University of Oklahoma, 48 to 101; Virginia Polytechnic Institute, 37 to 85; and University of Cincinnati, 25 to 75, the last being an increase of 200 per cent. From the efforts already under way for the school year 1939–1940 at many of the A.S.M.E. Student Branches, it is apparent that certain schools will more than double their membership for the 60th Anniversary of the founding of the Society. Following is a list of schools which had 100 or more student members during 1938–1939:

Student Branch	1938–1939	1937–1938
1 Purdue University	308	181
2 University of California	155	165
3 University of Illinois	144	107
4 Armour Institute	142	119
5 University of Michigan	140	167
6 Texas A.&M.	137	78
7 Pratt Institute	134	117
8 Brooklyn Poly	119	101
9 Case School	113	95
10 M.I.T.	111	112
11 Cooper Union	109	45
12 University of Minnesota	107	59
13 Rensselaer Poly	106	55
14 Stevens Institute	104	87
15 University of Oklahoma	101	48
16 Georgia Tech	100	71

1939 GRADUATES AND FACULTY OF BUCKNELL A.S.M.E. STUDENT BRANCH

A.S.M.E. Student Members Win Flying Scholarships to Boeing

TWO out of four winners of 1939 United Air Lines scholarships to Boeing School, Oakland, Calif., were student members of the A.S.M.E. They are Richard H. Burroughs, Jr., Princeton University, and Emil Kissel, College of the City of New York. The course will start on Sept. 25. Each will have his choice of a complete course in air-line operations and engineering, air-transport engineering, air-line mechanic and operations, air-line meteorology, or air-line technician, plus a solo pilot course consisting of 20 flying hours. Each scholarship is valued at $1260. Upon completion of the first quarter's work, one of the four will be selected to receive the air-line-pilot flying instruction of 285 hours, valued at $4600.

"The Stabilator for Longitudinal Stability and Control of Aircraft" was the title of the thesis written by student member Burroughs. He wrote concerning the idea of combining the functions of the stabilizer and elevator into one unit, thus his coined name of "stabilator," and discussed the advantages and disadvantages of such an installation from aerodynamic, structural, and economic viewpoints.

Student member Emil Kissel in his "Future of the Tailless Airplane" gave a brief history of this type of airplane, described the three different types which have been proposed in regard to their stability, controlability, strength, efficiency, and performance characteristics, and reviewed certain experiments which have been made in this field. His conclusions were that the tailless airplane is superior to the conventional type in many respects and would provide the ideal airplane for sport and transport use. He believes that designers are now resorting only to aerodynamic improvements for increased performance and suggests that a radical change is most desirable.

Three Quarters of June, 1939, Graduates Have Been Placed

THREE QUARTERS of the June, 1939, graduates from 193 American colleges, universities, technical, and normal schools have been placed in permanent positions up to the present, according to a survey made recently by King Merritt, of Minneapolis. Graduates this year had the brightest job prospects in two years. However, prospective employees are checking in detail every qualification and claim made by applicants, and are demanding as job essentials: Character, scholarship, personality, and adaptability. There is less emphasis on athletic prowess and campus popularity.

Teaching leads in demands for graduates' services, though only nine replies came from independent teachers' colleges. High-school teachers, especially those who can lead in extracurricular as well as classroom activities, are most sought. Engineering, unlike a year ago, outdistanced business administration. Some engineering placement bureaus report that engineering graduates are finding many new opportunities in sales engineering, industrial relations, personnel management, and other fields not open to such graduates a decade ago. In order of jobs being offered, mechanical engineering led, followed by chemical, electrical, and civil engineering. Mining and aeronautical engineering lagged far behind.

Campus recruiting is again on the increase; 60 to 70 industrial companies sent their representatives to the colleges during the spring of 1939. In volume of recruiting among the 1939 graduates the leading companies were: General Electric, Firestone Tire, Procter & Gamble, Goodyear Tire, Du Pont, General Motors, Sears Roebuck, U. S. Steel, Westinghouse, International Business Machines, Standard Oil of New Jersey, Eastman Kodak, Montgomery Ward, Armstrong Cork, and various subsidiaries of A.T.&T. Others of the 181 corporations frequently reported as campus recruiters include: Bethlehem Steel, Ingersoll Rand, Swift, Socony-Vacuum, Aetna Life Insurance, International Harvester, R. H. Macy & Co., Travelers Life Insurance, and Monsanto Chemical Company.

One way A.S.M.E. student members, who will be graduated in 1940, can attract the attention of the corporation representatives next spring is by preparing and presenting technical papers at the student-branch meetings and at the annual regional meetings of the A.S.M.E. Student Branches. Even if the speaker does not win a prize, his effort will count much with many personnel interviewers. Another factor in the favor of mechanical-engineering applicants will be their student membership in the A.S.M.E., a national society which will be 60 years old in April, 1940.

NORTH DAKOTA STATE A.S.M.E. STUDENT BRANCH

Student Branch Secretaries

Please Note!

REPORTS of meetings and inspection trips must be received at Society Headquarters on or before the sixth of the month in order to appear in next month's issue of MECHANICAL ENGINEERING. Example: All copy received up to Sept. 6 will be in the October issue, etc.

PHOTOGRAPHS of student member groups are always welcome for use in MECHANICAL ENGINEERING. Prints should be preferably glossy and of good contrast. However, send in everything you have and the editorial department will use those it can reproduce.

PUBLICITY is always good for the branch. Clippings from school and local newspapers should be sent in with your reports.

American Engineering Council

Presents

The News From Washington and Elsewhere

Registration of Engineers in Washington, D. C., Postponed

ALTHOUGH legislation providing for the registration of engineers in the District of Columbia did not become law before the first session of the 76th Congress adjourned, it passed the Senate on July 18 and was postponed by the Committee on the District of Columbia of the U. S. House of Representatives until Congress reconvenes in January, at which time the bill will be taken up again. This is more progress toward enactment than has hitherto been made by any of the similar measures introduced in preceding Congresses.

The proposed legislation, introduced by Senator King in the Senate (S. 1128) and Representative Randolph in the House of Representatives (H. R. 4792), has had the united support of the engineering organizations of the District of Columbia acting through the D. C. Council of Engineering and Architectural Societies.

Through extended conferences and hearings, the subcommittee of the Senate District Committee in charge of the legislation made every effort to present to the Senate a bill which would be representative of the point of view of engineers and engineering organizations within the District and was successful to the extent that the Senate passed the legislation as reported with almost no debate and with no amendments other than those recommended by the committee.

Encouraged by the approval of the Senate, those supporting the measure were hopeful that the House District Committee would report the Randolph bill favorably at its meeting of July 21. However, between the date of passage of the King bill in the Senate and the July 21 meeting of the House District Committee, representatives of several national organizations emphatically protested enactment of the legislation until its provisions had been broadened. Since the House District Committee had given no consideration to the matter other than to refer it to the District Commissioners and to its own subcommittee on the judiciary for a study and report, a few of its members felt that the committee did not have sufficient information on which to base action and expressed the belief that probably further hearings should be held. As a result the House District Committee voted to hold the Randolph bill in committee until Congress reconvenes in January.

Congress Acts to Improve Patent Procedure

OF THE several bills introduced into Congress to improve patent procedure, as a result of testimony before the Temporary National Economic Committee, five have been

passed by both the House of Representatives and the Senate. It is anticipated that they will be signed by the President promptly since the legislation proposed now has the approval of the Department directly affected, the Department of Commerce.

The bills, which were described in full in the August, 1939, issue of MECHANICAL ENGINEERING, p. 638, are H.R. 6872, 6873, 6874, 6875, and 6878.

A.E.C. Forums Published

AVAILABILITY of a third pamphlet covering proceedings of the forums conducted recently by the American Engineering Council is a reminder that many engineers may not have had an opportunity to read any or all of these informative discussions.

This most recent pamphlet includes the addresses and digest of discussion of the third forum, held in Washington, Jan. 12–13, 1939, on the subject "Public Affairs and the Engineer's Relation to Them." It comprises addresses on the plan and purpose of the forums, national planning, the economic status of the engineering and kindred professions, engineering aspects of government reorganization, engineering and economic factors in the size of business, and Dr. Vannevar Bush's address on "The Qualities of a Profession."

The first and second forums, also available in printed form, discussed "Employment and the Engineer's Relation to It," and "Invention and the Engineer's Relation to It."

New Planes, Guns, Test Basin Aid Defense

WITH the passage of a $293,985,547 supplemental Army appropriation bill, Congress has virtually completed the legislative action necessary to put into effect the expanded national-defense program called for by President Roosevelt. The bill provides the needed funds to increase the number of first-line Army industrial mobilization, construct a number of additional air bases, and augment the defenses of the Panama Canal. Money is also made available for personnel training required to expand the size of the Army establishment. Most of this will be expended by the Air Corps, to be trebled in strength in two years.

The War Department has also disclosed the development by the Ordnance Department of two new types of field guns, one firing a 100-lb shell a distance of 15 miles; the second a powerful anti-tank gun of 37-mm caliber firing a shell that will pierce $1\frac{1}{2}$-in. armor plate at a distance of $\frac{1}{2}$ mile. Both are included in the expanded program of manufacture.

The Navy Department on June 30 accepted from the contractors the $3,500,000 David W. Taylor Experimental Model Basin on the bank of the Potomac River at Carderock, Md. The basin will be put in use as soon as precision testing equipment can be installed to test scale models of ships designed both for the Navy and the merchant marine. It consists of two tanks 1200 ft long, one 55 ft wide and 20 ft deep; the other 22 ft wide and 10 ft deep.

Trade Cotton for Rubber

Supplementing the acquisition by this country of strategic minerals by outright purchase approved by Congress last month, the United States and Great Britain have agreed on an exchange of 600,000 bales of cotton for approximately 175,000,000 pounds of rubber, the exact amount depending upon price averages for the last six months. Both countries will hold the acquired materials off the commercial market for a period of seven years for use only in case of a major war emergency.

The treaty negotiated with British authorities by U. S. Ambassador Joseph P. Kennedy, was promptly ratified. Legislation to authorize the Commodity Credit Corporation to obtain title to the cotton, which is technically held by the government as security for loans to the producers, and to handle other details of the exchange was immediately introduced.

Negotiations are also under way with other countries which will result, it is hoped, in the exchange of surplus American cotton and wheat for tin and other critical war materials.

President Christie Honored

AT THE 1939 Commencement of the Stevens Institute of Technology, A. G. Christie, President, The American Society of Mechanical Engineers, received the honorary degree of Doctor of Engineering. Other A.S.M.E. members similarly honored were William LeRoy Emmet of the General Electric Company, and William S. Knudsen, president, General Motors Corporation. Mr. Knudsen made the commencement address to the graduates.

A.S.T.M. Issues Specifications for H-T and H-P Piping

TO MAKE specifications covering steel materials for high-temperature and high-pressure service available in convenient compact form, the A.S.T.M. has issued a special compilation giving 18 specifications covering carbon-steel and alloy-steel pipe and tubing, castings, forgings, and bolting. Several of the specifications have been approved as American Standards by the A.S.A. and a number have been adopted from the Boiler Code of the A.S.M.E. Copies of this 135-page publication, heavy paperboard cover, spiral ring binding, can be obtained by members from the A.S.M.E. Publication-Sales Dept., 29 West 39th St., New York, N. Y., at $1.25 per copy.

Bureau of Standards Revises Grinding-Wheel Practice

THE current revision of Simplified Practice Recommendation R45-32, Grinding Wheels, has been accorded the required degree of acceptance by the industry, and is to become effective June 1, 1939, according to an announcement by the Division of Simplified Practice, National Bureau of Standards, Washington, D. C. The revised recommendation will be identified by R45-39, and may be obtained without charge from the Division.

(*A.S.M.E. News continued on page 702*)

AT THE DINNER OF THE A.S.M.E. APPLIED MECHANICS DIVISION DURING ITS MEETING IN NEW YORK IN JUNE
(An account of the meeting appeared in the July issue of MECHANICAL ENGINEERING, page 561.)

To Measure—MOISTURE CONTENT
ELECTRICALLY

MOISTURE is an elusive agent—all-pervading in nature and difficult to detect, difficult to eliminate or control. And when there's moisture in supposedly dry annealing gases, high-carbon steel decarburizes and becomes unsatisfactory for many uses. Razor blades made from it have poor edges; automobile and airplane gears do not hold up in service.

To help eliminate this handicap, G-E engineers were asked to devise an instrument which would improve annealing and heat-treating operations by determining the moisture content of gases. As "Headquarters for Electrical Measurement," the G-E laboratories had already solved other tough problems for industry—had made instruments to measure lightning surges and the trickle of electrons in a vacuum, instruments to measure color exactly and instruments to unscramble sound waves; and now they set to work on measuring moisture.

The result was a portable potentiometer which measures the dew point, or temperature at which moisture will condense from a sample of gas. (It's described in Publication GEA-2630, which is yours for the asking.) The moisture condenses on a thin, metallic mirror connected to a thermocouple and then to an indicating instrument. An operator regulates the flow of the cooling medium against the back of the mirror until the exact condensation point, or dew point, is reached and temperature readings can be made. Thus, another measurement problem was solved.

G-E engineers have brought to electrical measurement the experience of fifty years in almost every field of electrical endeavor. That's why there are accurate G-E instruments to measure almost any quantity—current, voltage, resistance, watts, frequency, power-factor—in dozens of standard styles, indicating and recording, and in ratings to fill every need. If you have a problem that involves measurement, remember General Electric, Schenectady, N. Y., as

HEADQUARTERS FOR ELECTRICAL MEASUREMENT

GENERAL ELECTRIC

430-153

Men and Positions Available

Engineering Societies Employment Service

MEN AVAILABLE[1]

MECHANICAL ENGINEER, 22, Purdue, 1939, desires to learn power-plant operation. Good health. Location immaterial. Available now. Me-347.

MECHANICAL AND STRUCTURAL ENGINEER; 14 years' mechanical and structural design, estimating, sales and installation of materials-handling equipment and structures. Can manage engineering department efficiently. New York State professional license. Me-348.

INSTRUCTOR, 26, with M.M.E. Several years, industrial experience in estimating, vibration, experimental. Some teaching as graduate assistant and as teacher for draftsmen and student engineers in industry. Me-349.

SUPERVISOR OF REAL ESTATE, management. Broad information of prices and services. Personnel and labor experience. Annapolis graduate, 1931. Has labor, utility, bank, institution, and owner contacts; 5 years' commercial experience. Me-350.

[1] All men listed hold some form of A.S.M.E. membership.

MECHANICAL ENGINEER, 1938 graduate. Interested in sales and production engineering. Some practical machine design and building-estimation experience. Desires position within commuting distance of New York, N. Y. Me-351.

MECHANICAL ENGINEER, 22, single. Recent graduate Stevens Institute of Technology. Interested in laboratory or production and maintenance work. Willing to start at bottom. Location preferred Eastern U. S. Me-352.

MECHANICAL ENGINEER, 26, single. Four years' experience machine and structural-steel design, power-plant operation, reports, estimates, sales engineering. Desires plant operation, construction, testing, or sales. Me-353-51-Chicago.

MECHANICAL ENGINEER, 26, single, University of Illinois graduate, 1935. Three years' experience in shops and engineering department of large valve and fitting manufacturer; 1 year Lieutenant, Corps Engineers, U. S. A. Me-354-47-Chicago.

MECHANICAL ENGINEER, 30, married. Four years' designing precision instruments, tools, jigs, fixtures, and special machines for manufacturing same. Inspecting and testing. General factory trouble shooter, photographer, and contact man. Me-355.

AIR-CONDITIONING ENGINEER, 36, graduate, licensed New York, employed. Fifteen years' broad engineering experience design and construction of thermal, hydraulic, mechanical, electrical equipment; heating, ventilating, refrigeration, power distribution, air conditioning. Me-356.

MANAGEMENT ENGINEER, 20 years' experience design, production, plant layouts, job analysis, routing and planning methods, improvements of manufacturing processes, cost reductions on direct and indirect items. Location, immaterial. Me-357.

MECHANICAL ENGINEER, 26, Purdue B.S., M.E., married. Two years' experience with railway-supply company, drafting, inspection, testing materials, calculating, estimating. Now employed. Interested in sales. Desires opportunity with progressive company. Me-358.

CONSULTANT-PROFESSIONAL ENGINEER available to take over full responsibility for selection, design, or erection of mechanical equipment in commercial or institutional buildings or industrial plants, for architects, contractors, corporations, etc. Location East or South. Me-359.

COAL-MINE MECHANICAL AND ELECTRICAL ENGINEER, 25 years' experience in design, construction, and operation of coal-mining plants. Specialty is coal cleaning and preparation. Me-360.

RECENT MECHANICAL ENGINEERING GRADUATE desires employment with reliable company. Would prefer hard work as laborer for privilege of becoming established in mechanical-engineering field. Location and salary no point. Me-361.

MECHANICAL ENGINEER, 27, employed. Three years' production experience (management, maintenance) with small concern. Mechanical creative ability. Seeking change to mechanical development phases of production. Me-362.

GRADUATE MECHANICAL ENGINEER, 27. Three years' power-plant experience. Instrument maintenance. Boiler feedwater and steam-temperature control (air operated). Coefficient of heat-transfer tests and calculations on condensers. Location preferred East. Me-363.

POSITIONS AVAILABLE

DESIGNER with wide experience in design of office equipment. Must have originality and ability to carry through complete design. Only man capable of assuming full responsibility for development engineering jobs will be considered. Should have design experience with companies manufacturing adding machines, typewriters, cash registers, etc. Salary, $3500–$4000 a year. Location, New England. Y-4072.

CHIEF DRAFTSMAN with experience in merchant-ship construction. Also, leading draftsmen for following: Machinery-space arrangement, electrical work, steel work, ventilation and heating, piping, accommodations, and cargo car. Only men with experience in merchant-ship construction will be considered. Location, South. Y-4450.

GRADUATE MECHANICAL ENGINEER to act as superintendent of power of number of small Diesel hydro- and steam-power plants. Must have about ten years' experience in operation and maintenance of power plants, and be able to speak Spanish. Salary, $5000–$6000 a year. Location, South America. Y-4462.

ENGINEER, 30–35, preferably with textile experience, who can qualify as executive for all-round work. Apply by letter giving full details of background and experience, and enclosing recent photograph. Location, New England. Y-4466.

INSTRUCTOR in mechanical engineering. Will be expected to teach some evening as well as day classes. Applicant with previous teaching or tutoring experience, practical experience, and graduate studies will be given preference. Apply by letter giving complete statement of education, practical experience, reason for desiring to teach, subjects in which applicant feels best qualified to give instruction, references, and enclosing recent photograph. Salary, $1800 for school year. Location, South. Y-4467.

GRADUATE ENGINEER, 35–40, for company manufacturing welding pipe fittings such as return bends, elbows, tees, reducers, heads, etc. Processes cover wide range of metalworking consisting mainly of tubular-drawn products on hydraulic presses, products made on forging machines, consisting of upsetting operations, etc. Applicant must have experience in metalworking in one or more of fields listed, and must be capable of designing dies, making improvements in company's present methods of forming metals, etc. Location, South. Y-4487.

GRADUATE MECHANICAL OR ELECTRICAL ENGINEER with several years' design and maintenance experience. Sales experience also de-

(*A.S.M.E. News Continued on page 704*)

A.S.M.E. Calendar

of Coming Meetings

September 4–8, 1939
Fall Meeting
New York, N. Y.

October 5–7, 1939
Joint Meeting of A.S.M.E. Fuels and A.I.M.E. Coal Divisions.
Columbus, Ohio

October 5, 1939
Machine Shop Practice Division to hold "A.S.M.E. Day" at Machine Tool Congress, Cleveland, Ohio

October 12–13, 1939
Wood Industries Division
Boston, Mass.

November 2–4, 1939
Joint Meeting with American Institute of Physics in a Symposium on Temperature Measurement, New York, N. Y.

December 4–8, 1939
Annual Meeting
Philadelphia, Pa.

May 1–3, 1940
Spring Meeting
Worcester, Mass.

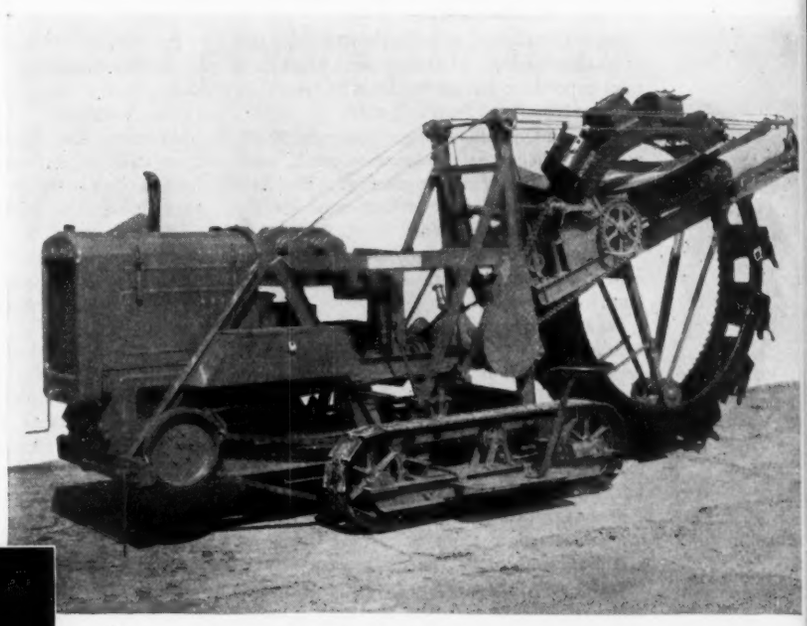
June 17–21, 1940
Semi-Annual Meeting
Milwaukee, Wis.

(*For coming meetings of other organizations see page 22 of the advertising section of this issue*)

How to Reduce THE DRAG OF *Deadweight*

ON OPERATING COSTS AND SALES

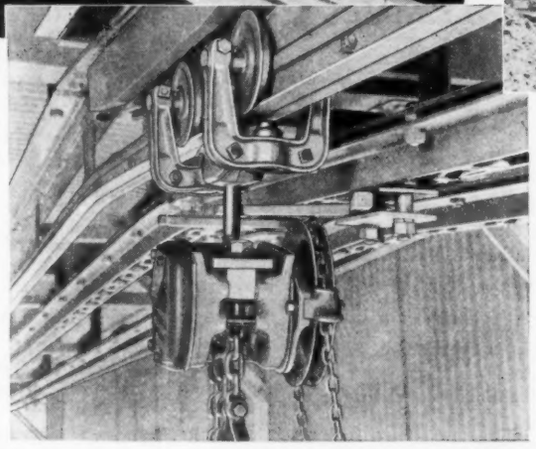
Dead weight exacts a terrific toll in excess fuel, power, handling and shipping costs. It's a drag on operating costs and frequently a resistance to sales effort. Relieve your equipment of this disadvantage. Redesign it! For longer life, greater flexibility, lower operating cost, and lower production cost, use forgings. Pound for pound forgings are far stronger. Forging produces maximum strength in lighter sectional thicknesses through scientific weight distribution. In forgings, strength is not achieved by metal bulk but through concentration of grain structure and fiber formation at points of greatest shock or strain. Forging kneads metal into a dense mass of hoarded strength; avoids concealed defects and provides a wide margin of tensile and torsional strength. Forgings have less metal to machine off, resulting in savings in cost of finished parts, and with forgings it is possible to obtain uniformity of physical properties in the exact degree desired after heat treating. Consult a competent forging engineer.



. . . *Use Forgings*

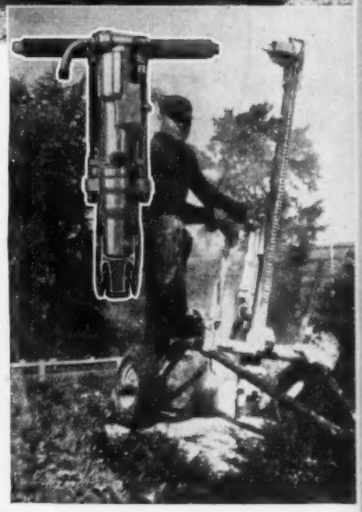
"We have gained many advantages by using forgings" states the Cleveland Trencher Company. "There are no blow holes, uniform heat treatment is possible, the structure of the forging makes machining easier, resulting in a material saving of our tools. But the most important effect derived from our use of forgings is lessening of dead weight. Our use of forgings, wherever possible, has resulted in our being able to produce the lightest machine of its capacity in the world!"

rm weather holds no rors for passengers on ses equipped with rukesha Air Condition- . Forgings help reduce ight of air conditioning t designed for "Tropic-" installations in yhound buses. Manu-turer says forgings are ferred for these vital wer units because ructure and ductility" primary essentials for h parts. Speaking of duction advantages, nufacturer refers to: ximum strength with imum weight." Crank-ft and connecting rods this unit are among rgings used in its rication.



Forgings reduce dead weight, furnish invulnerable strength and durability in renowned Athey "Forged-Trak" wood and log hauling equipment. The Athey Truss Wheel Co., manufacturers of this equipment, say that they use forgings "to secure maximum strength for a minimum of weight, better physical properties, better grain structure, better heat treatment; reduced cost and elimination of hidden defects."

Forgings facilitate light weight design of Sullivan Hard Rock Drilling Machine. *Manufacturer says:* "we use forgings because we have found forgings to be stronger than castings. Forgings play an important part in the reputation our machines have gained for low upkeep cost. With Forgings, less material is wasted, less time is spent turning down the various parts to correct size."



ety and faultless performance is imperative in overhead handling equipment. kage of vital load bearing parts cannot be tolerated. American Monorail equip-t, designed for maximum load carrying capacity, employs numerous forged parts provide the necessary wear and greatest strength at points of greatest load stress. rgings are used wherever parts must undergo strain and constant wear.

HERE ARE NO SUBSTITUTES FOR FORGINGS

ROP FORGING ASSOCIATION

05 HANNA BUILDING · CLEVELAND, OHIO

SYMBOLIC EMBLEM OF THE DROP FORGING ASSOCIATION

sirable. Position involves sales, sales correspondence, market research, new-product development, etc. Salary, about $175 a month. Location, New York State. Y-4502.

SALES ENGINEERS, ages 28–38, to handle line of leather belting and accessories. Must have sales experience and be residents of central or western New York State. Y-4508.

DESIGNERS, graduate engineers, ages 30–40, with experience in transmission work, especially in design of marine gearing. Positions are in the nature of group leaders or leading men. Location, New York State. Y-4523.

GENERAL SALES MANAGER with experience in field of metal stampings. Location, New England. Y-4524.

SALES ENGINEER, 30–40, mechanical, to handle special sales problems as well as dealer sales organization from home office in fire-prevention field. Experience in this field not necessary, but applicant must be aggressive, have good personality, and demonstrated record of sales ability. Salary, $300 a month. Location, Ohio. Y-4537.

SALES ENGINEER, 32–40, with background in mechanical engineering, sales experience and acquaintanceship in power-plant equipment, stokers, etc. Dealer organization setup. Salary, $300 a month with bonus arrangement. Headquarters, Middle West. Y-4538.

CHIEF DRAFTSMAN, graduate mechanical engineer, good executive, to direct drafting room comprising seven designers. Must have original ideas concerning designs as company is in jobbing machine-shop business. Company operates it own forging, machine shops, and foundries. Salary, $300 a month. Location, Ohio. Y-4540.

MECHANICAL ENGINEERS, one or two, for development work. Work will be on design of company's products, consisting of pipe couplings, clamps, sleeves, and fittings. Must have broad general experience, as well as ingenuity and imagination. Location, East. Y-4551.

ENGINEER with experience in hydraulic motors, control valves, regulators, etc., for operation of machinery. Machine-tool experience in connection with this work would be desirable. Location, East. Y-4553S.

PRODUCTION MANAGER, 23–38, for plated silverware and novelty plant employing about two hundred persons. Location, New York State. Y-4554.

AERONAUTICAL ENGINEERS, with five or more years' aircraft-engineering experience, to handle completely design and supervision of engineering on following units: Fuselage, wing and center section, landing gear and hydraulics, equipment, power-plant and fuel system, controls, empennage, electrical and radio, stress, and checking. Work will be on four-engine all metal transport airplanes. Apply by letter enclosing recent photograph. Location, West. Y-4587S.

MECHANICAL ENGINEERING GRADUATE, June, 1939, age 27, married. Some drafting, machine-design, and mechanical experience. Desires position leading to design, or in maintenance and repair, or assistant supervisory capacity. Me-364-102-Chicago.

MECHANICAL-ELECTRICAL ENGINEER, graduate, professional license. Sixteen years' executive experience plant layout, maintenance, production, cost-saving manufacturing field. Desire connection executive or sales-engineering building products, industrial equipment, or control. Me-365.

FACTORY MANAGER OR SUPERINTENDENT. Practical management and engineering background with broad diversified manufacturing experience. Thorough knowledge of modern production methods; materials; equipment; costs; plant upkeep; organization and labor relations. Me-366.

MECHANICAL-METALLURGICAL ENGINEER, 26, single, Stevens graduate; 20 months' extensive and varied training course with prominent company; 2 years' broad metallurgical application. Now employed, desires connection affording opportunity for greater progress. Me-367.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after September 25, 1939, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references.

Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Reelection; Rt = Reinstatement; Rt & T = Reinstatement and transfer to Member.

NEW APPLICATIONS

For Member, Associate, or Junior

ANDERSON, CARL G., Chicago, Ill.
BUCK, WM. NOEL, Ft. Wayne, Ind.
BOMER, EDGAR THOS., Brooklyn, N. Y.
CHRISTY, HOWARD A., Philadelphia, Pa.
DUNGLINSON, BURTON, London, Eng. (Rt)
GOLDSMITH, PHILIP H., Wilmington, Del.
GRANNISS, EDWARD R., Larchmont, N. Y.
HAUPT, H. HAROLD, Pittsburgh, Pa.
HERRICK, GERARD P., New York, N. Y.
HYDE, GEORGE GAYLOR, New York, N. Y. (Rt & T)
JOHNSON, R. P., Philadelphia, Pa.
KING, ALFRED T., Upper Darby, Pa.
KINNEY, J. F., Humboldt, Kansas
MARCELLUS, B. V., San Francisco, Calif. (Rt)
MARTIN, LEO M., San Francisco, Calif.
MCCLURE, JOHN B., Scotia, N. Y.
MCLAUGHLIN, J. R., Des Moines, Iowa
NEWTON, C. ARTHUR, Prospect Park, Pa. (Rt)
PIERCE, EDGAR M., Buffalo, N. Y.
PRINCE, WILLIAM, Hasbrouck Hgts., N. J.
RUMPF, H. E., Milwaukee, Wis.
SALIBIAN, MIHRAN, Bagdad, Iraq
SINGLETON, JOHN C., JR., Plainfield, N. J.
THOMPSON, H. G., Toronto, Canada
THOMPSON, ROSS E., Albuquerque, New Mex. (Rt)
WAGNER, WARREN O., Reno, Nev.

CHANGE OF GRADING

Transfers to Fellow

HELANDER, LINN, Manhattan, Kans.
MUMFORD, ALBERT R., New York, N. Y.

Transfers to Member

FAAST, FRANK E., Brooklyn, N. Y.
FROBERG, HAROLD G., Chicago, Ill.
LEONHARD, FREDERICK J., Shaker Heights, Ohio
MARMONT, E. LEONARD, Chicago, Ill.
MYERS, GRAFTON S., JR., Chattanooga, Tenn.
TAYLOR, EDWARD C., Boston, Mass.

Necrology

THE deaths of the following members have recently been reported to the office of the Society:

BECK, JAMES D., May 25, 1939
BIGELOW, CHARLES H., June 10, 1939
CASLER, HERMAN, July 20, 1939
DURBIN, PAUL C., July 14, 1939
FORDYCE, JOHN R., June 9, 1939
HILTON, ERIC A., May 2, 1939
HOUGHTON, BERT, June 17, 1939
LAGER, CARL A., July 17, 1939
LISTER, ROBERT R., Nov. 16, 1938
LOWRY, GEORGE A., May 3, 1939
MACGREGOR, WALLACE F., June 18, 1939
MUNSON, EDMUND G., Feb. 24, 1939
PIERSON, JOE W., Feb. 5, 1939
SHEPARD, GEORGE H., July 30, 1939
SHRIVER, HARRY T., Jan. 6, 1939
SOUTHERN, GILBERT WALLHEAD, Jan. 27, 1939
WALDRON, FREDERICK A., July 11, 1939

A.S.M.E. Transactions for August, 1939

THE August, 1939, issue of the Transactions of the A.S.M.E. contains the following papers:

TECHNICAL PAPERS

Pitot Tubes in Large Pipes, by Edward S. Cole and E. Shaw Cole
Investigation of Errors of Pitot Tubes, by C. W. Hubbard
Changes in a High-Pressure Drum to Eliminate Recurrence of Cracks Due to Corrosion Fatigue, by A. E. White
To the Question of Balancing Reciprocating Weights in Steam Locomotives, by A. I. Lipetz
The Resistance to Relaxation of Materials at High Temperature, by E. L. Robinson

DISCUSSION

On previously published papers by H. L. Harrington and E. B. Strowger; and P. L. Heslop and G. A. Jessop